Preliminary Results on Nickel Concentrations in Soil, Leaves and Fruits of Apple and Peach Orchards in Northern Greece

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Abstract: Relatively little is known about the role of Ni in plant nutrition, physiology and metabolism, especially in woody perennial species. Preliminary results in 2004 in 28 samples of various fruits of several regions of Greece, showed that in 10 samples Ni concentration was zero. The scope of this research was to make a first attempt to investigate whether the previous results was a result of Ni deficiency in the soils or an inability of certain species to absorb Ni from the soil. The research was carried out in two orchards with different soil Ni concentrations. In both orchards, the higher Ni concentration in apple fruits was measured for the cultivar Red Chief. However, leaf Ni concentration of the same cultivar wasn't so high indicating that the translocation and redistribution of Ni to the fruits is a characteristic of this cultivar.

Keywords: Apple, Fruit, Leaf, Nickel, Peach.

1. INTRODUCTION

The discovery in 1975 that nickel (Ni) is a component of the enzyme urease [1], which is present in a wide range of plant species, led to renewed scientific interest on the role of Ni in higher plants. Its essentiality to higher plants was proposed by Brown *et al*. [2]. Nickel belongs to metals showing considerable mobility, in particular at acid soil environment [3]. There is a relative abundance of Ni essentially in all soils (>5 kg ha^{-1}) whereas low levels thought to be needed by plants (about 1–100 ng g^{-1} dry weight) [4]. Several researchers have reported growth responses of plants to Ni fertilization under field conditions. Ni-deficient soybean (*Glycine max* L.) accumulate toxic levels of urea in their leaflet tips because of a depression in urease activity in their leaves [5]. Walker *et al*. [6], working with cowpeas (*Vigna unguiculata* L.), suggested that Ni participates in N metabolism of legumes during the reproductive phase of growth. Ni-deficient tomato plants (*Lycopersicon esculentum* L.) developed chlorosis in the newest leaves and, ultimately, necrosis of the meristem [7]. Whereas many proteins contain Ni, Ni nutrition of higher plants and its physiological significance, especially to woody perennials, have received little attention [8]. There are several enzyme systems (NiFe-hydrogenase, carbon monoxide dehydrogenase, acetyl-CoA decarbonylase synthase, methyl-coenzyme Mreductase, superoxide dismutase, Ni-dependent glyoxylase, aci-reductone dioxygenase, and methyleneurease) in bacteria and lower plants that are activated by Ni [9]; however, the activation of urease appears, to date, to be the only enzymatic function of Ni in higher plants [10].

Relatively little is known about the role of Ni in plant nutrition, physiology, and metabolism, especially in woody perennial species. Ni deficiency of pecan (*Carya illinoinensis)* [Wangenh.] K. Koch is the most well known deficiency in trees. Morphological symptoms of Ni deficiency in pecan were also reported [11]. However, there is a dearth of information regarding the influence of Ni deficiency on metabolism and associated biochemical symptoms of woody perennial species. Ni concentration in leaves of various plant species ranges from 0.05-5 mg kg^{-1} dry weight. N concentration of soils has a high correlation with plant Ni concentration since Ni is absorbed easily from the plant's roots and is mobile inside the plants [12]. Ni concentrations >10 mg kg^{-1} are considered toxic in sensitive species and >50 mg kg^{-1} in tolerant species [13].

Preliminary results in 2004 in 28 samples of various fruits of several regions of Greece, showed that in 10 samples Ni concentration was zero (Stylianidis unpublished data). The scope of this research was to make a first attempt to investigate whether the previous results was a result of Ni deficiency in the soils or an inability of certain species to absorb Ni from the soil.

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2. MATERIALS AND METHODS

The research was conducted in two orchards in Naoussa area in northern Greece (long. 22^0 12' 0'' E; lat. $40^0$29'04''N; elevation 270m). In the first orchard (A) of 1.5 ha, the peach cultivars Sun Crest and Andross were cultivated grafted on GF677 rootstock. The trees were 12 years old, trained as an open vase shape and planted at 3.5 x 4 m apart. At the same orchard the apple cultivars Jonagold, Red Chief, Golden Delicious and Firiki were cultivated grafted on M26 rootstock. The trees were 15 years old, trained as a palmette and planted at 3.5 × 3m apart. In a second orchard (B) of 3 ha located in another nearby area the apple cultivars Golden B, Firiki, Lutz Golden, Starckrimson, Golden Delicious, Imperial Double Red Delicious and Red Chief were cultivated. The trees were 18 years old, grafted on M26 rootstock, trained as a palmette and planted at 3.5 × 3m apart. Soil analyses data of the two orchards are given in Table **1**. Leaf samples for leaf analyses were collected in mid July. Leaves were collected from the middle of moderately vigorous shoots from each tree around the periphery, at shoulder height. Fruit samples were collected at the harvest period of each cultivar. All samples were initially washed once with tap water and twice with distilled water. Leaf samples were dried in a forced draft oven at 68°C for 72h and ground in a mill to pass a 30 mesh screen. Fruits were freeze dried. Nickel was measured in ICP mass spectrometry after extraction with DTPA [14].

3. RESULTS AND DISCUSSION

Nickel concentration of the soil of orchard 'B' was significantly higher than that of orchard 'A' (27.82 and 2.27 ppm respectively).

In orchard 'A', Ni concentrations in apple leaves were higher than peach leaves (Table **2**). The highest Ni concentration in apple leaves was measured in the cultivar Golden Delicious.

In orchard 'B' the highest Ni concentration in apple leaves was measured in the cultivar Golden B and the lowest in the cultivar Red Chief (Table **3**).

Leaf Ni concentrations of orchard 'B' were higher than those of orchard 'A'. The results are in accordance with the fact that soil Ni concentration is highly correlated with plant Ni concentrations since Ni is absorbed easily from the plant's roots and is a mobile element, therefore is translocated easily in the various plant organs [15].

Table 1: Soil Analyses Data of the Two Orchards

Parameters	Units	'A'	'B'
Texture		L	SCL
Clay	%	22	26
pH		7.8	7.2
EC	(mS/cm)	0.43	0.39
Organic matter	%	3.5	1.0
$CaCO_3$	%	21.3	1.8
NO_3-N	ppm	12.6	4.4
P	ppm	41	4.6
K	ppm	56	49
Mg	ppm	448	1040
Ca	ppm	>2000	>2000
Fe	ppm	23.6	42
Zn	ppm	12.5	1.4
Ni	ppm	2.27	27.82
Mn	ppm	24.4	31
Cu	ppm	47	3.3
B	ppm	0.21	1.4

Table 2: Nickel Concentrations in Peach and Apple Leaves of Orchard 'A'

Peach Cultivars	Ni (ppm Dry Weight)
Sun Crest	1.44±0.21
Andross	1.16±0.19
Apple Cultivars	
Golden Delicious	4.13±0.44
Jonagold	3.47±0.39
Red Chief	3.28±0.35
Firiki	3.15±0.38

Table 3: Nickel Concentrations in Apple Leaves of Orchard 'B'

Apple Cultivars	Ni (ppm Dry Weight)
Golden B	24.45±2.98
Firiki	21.63±2.45
Lutz Golden	21.36±2.63
Starckrimson	20.66±2.39
Golden Delicious	19.56±2.35
Imperial Double Red Delicious	18.05±2.21
Red Chief	16.73±2.01

In orchard ‘A’, the highest Ni concentration in apple fruits was measured in the cultivar Red Chief, while lower concentrations were measured for the cultivars Golden Delicious and Jonagold (Table **4**).

Table 4: Nickel Concentrations in Apple Fruits of orchard ‘A’

Apple Cultivars	Moisture (%)	Ni (µg/100g Fresh Weight)
Golden Delicious	85.46	2.0±0.31
Jonagold	84.12	1.9±0.22
Red Chief	85.34	5.4±0.68
Firiki	85.46	3.9±0.45

In orchard ‘B’, higher Ni concentration in apple fruits was measured in the cultivars Red Chief, while lower concentrations were measured for the cultivars Firiki and Lutz Golden (Table **5**).

Table 5: Nickel Concentrations in Apple Fruits of Orchard ‘B’

Apple Cultivars	Moisture (%)	Ni (µg/100g Fresh Weight)
Golden B	84.45	6.5±0.78
Firiki	85.92	3.0±0.39
Lutz Golden	84.16	2.0±0.24
Starckrimson	85.12	7.0±0.88
Golden Delicious	84.28	6.3±0.72
Imperial Double Red Delicious	83.84	6.0±0.71
Red Chief	85.90	9.3±0.99

In both orchards, the higher Ni concentrations in apple fruits were observed in the cultivar Red Chief. However, leaf Ni concentration of the same cultivar wasn’t so high indicating that the translocation and redistribution of Ni to the fruits is a characteristic of this cultivar. On the contrary, Ni concentration of fruits of the cultivar Firiki in orchard ‘B’ was low but in the leaves Ni concentration was high. In other studies, Ni concentration in apple fruits ranged from 0.5 μg/100g to 9.7 µg/100g of fresh weight [16]. The influence of soil geochemistry and irrigation practices among other factors may be responsible for the variability of Ni concentrations.

In conclusion, in orchard ‘B’ having higher Ni soil concentration than orchard ‘A’, both in leaves and fruits, Ni concentrations were higher than those of orchard ‘A’. In both orchards, the higher Ni concentrations in apple fruits were observed in the cultivar Red Chief. From the above preliminary results it appears that the studied cultivars showed a different capacity of Ni absorption from the soil but also a different capacity for translocation and distribution of the element in leaves and fruits. However, further research is needed for the study of Ni absorption, translocation and distribution of various fruit trees.

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