GENERAL ASPECTS OF FRUIT TREES WITH RESPECT TO MINOR NUTRIENTS IN KOREA

Hee-Seung Park[1] and Jong-Seung Choi[2]
[1]Department of Fruit Tree Cultivation, National Horticultural Research Institute, RDA
475 Imok-Dong, Suwon 440-310, Korea
[2]Division of Horticulture and Landscape Architecture, Pai Chai University
Doma-dong, Seo-gu, Taejoen 302-735, Korea

ABSTRACT

Research into toxicity and deficiency of minor nutrients in soil has been carried out in Korea since the 1960s. Soils in Korea tend to have a low pH and a low organic matter content. Physical properties of some orchard soils are unsuitable for the cultivation of fruit trees. The boron content of orchard soils has increased recently, compared to the low levels of the 1960s. Injuries from boron levels are common. Deficiency is observed in apple, grape, and peach orchards, and toxicity in apple and pear orchards. Most orchards have excessive manganese levels, especially apple and persimmon orchards. There are few reports of physiological problems concerning iron or zinc.

FRUIT CULTIVATION IN KOREA

The introduction of improved cultivars and the growth in consumers' incomes has resulted in a marked increase in the number of commercial orchards in Korea in recent decades. The most common fruit grown is apple, followed by persimmon, citrus, grape, pear, peach, plum, in that order.

SOILS IN KOREAN ORCHARDS

The parent materials of orchard soils in Korea are mainly granite and granite gneiss. The soil pH is thus very low, and this acidity is made worse by excessive rainfall. More than 59% of the total orchard area is on sloping land with a gradient of more than 4°. The soil of slopeland orchards is very shallow, and the organic matter content is low. Most orchards are fairly new, so that their soils have not been cultivated for long. According to soil analysis carried out in the 1960s and 1980s, the soil pH in apple orchards was lower in the 1960s than in the 1980s, while the soil organic matter content was higher. In contrast, the pH of soil in pear orchards was higher in the 1960s than in the 1980s, while the organic matter content was lower.

NUTRITIONAL DIAGNOSIS OF FRUIT TREES USING LEAF ANALYSIS

Leaf analysis to diagnose the nutrient status has been carried out in Korea since the 1960s, and is the main analytical method used today. Estimated critical levels (ECLs) in nutrients have been investigated by leaf analysis of apple, pear, grape, peach and persimmon. However, estimated critical levels for minor nutrients could not be determined, because these vary according to the variety and species of fruit tree, and the kind of microelement.

The micronutrient levels in persimmon leaves were investigated in 1992. The results showed that the levels of boron and manganese varied widely in different orchards, while the ECLs with regard to iron content fell outside normal levels in most orchards (Table 1, Table 2 and Table 3).

Keywords: apple, boron, deficiency, Korea, manganese, micronutrients, orchard, pear, persimmon, toxicity

Table 1. Mineral concentrations and estimated critical levels in leaves of 'Kyk-kwang' apple trees in the 1960s

Element	Average	Range	Estimated critical levels			% of normal orchards
			Deficiency	Normal	Excess	
N (%)	2.60	2.06 - 3.14	<2.05	2.47 - 2.89	> 3.31	67.3
P (%)	0.166	0.111-0.262	<0.093	0.139-0.185	>0.231	81.1
K (%)	1.45	0.68-2.07	<0.81	1.31-1.81	>2.31	93.4
Ca (%)	1.04	0.73-1.63	<0.71	0.91-1.11	>1.31	56.8
Mg (%)	0.242	0.130-0.402	<0.134	0.220-0.306	>0.392	55.4
Mn (mg/L)	341.2	93.8-1,063	-	-	-	-
Fe (mt/L)	103.9	25-539	-	-	-	-
B (mg/L)	36.4	20.3-112.8	<12.8	23.9-35.5	52.1	

Data were measured for 5 years from 1962 to 1966 on 158 orchards.
Source: Yun 1967a

Table 2. Mineral concentrations and estimated critical levels in leaves of 'Keumchonchu' pear trees in the 1960s

Element	Average	Range	Estimated critical levels			% of normal orchards
			Deficiency	Normal	Excess	
N (%)	2.15	1.50-2.83	<1.31	1.89-2.47	>3.05	61.6
P (%)	0.119	0.089 - 0.177	<0.065	0.101-0.137	>0.173	78.2
K (%)	1.94	1.08-5.94	<0.65	1.47-2.29	>3.11	68.4
Ca (%)	1.49	0.82-2.45	<0.65	1.19-1.73	>2.27	66.9
Mg (%)	0.295	0.180-0.434	<0.162	0.256-0.350	>0.444	60.8
Mn (mg/L)	273.3	70-913	-	-	-	-
Fe (mg/L)	158.5	35.0-430.5	-	-	-	-
B (mg/L)	32.1	17.5-59.0	<4.5	23.7-42.9	>62.1	71.4

Data were measured for 5 years from 1962 to 1966 on 55 orchards.
Source: Yun 1967a

Table 3. Mineral concentrations and estimated critical levels in leaves of 'Buyou" persimmon trees in the 1990s.

Element	Average	Range	Estimated critical levels			% of normal Orchards(%)
			Deficiency	Normal	Excess	
N (%)	2.52	1.05-3.66	<1.768	2.137-2.875	>3.163	72.2
P (%)	0.137	0.11-0.20	<0.072	0.119-0.152	>0.199	80.5
K (%)	2.411	1.53-3.27	<1.278	2.038-2.797	>3.552	66.4
Ca (%)	0.911	0.388-1.36	<0.602	1.110-1.512	>1.192	15.0
Mg (%)	0.357	0.161-0.722	<0.320	0.402-0.481	>0.563	19.5
Fe (mg/L)	160.6	84-421	<6.7	52.3-11.3	>170.3	8.0
Mn (mg/L)	1,352	122-3,211	<970	1,110-1,249	>1,389	43.6
B (mg/L)	49.9	15-150	<5.8	23.5-41.2	>58.9	25.7

Data were measured for 3 years from 1990 to 1992 on 68 orchards

PHYSIOLOGICAL INJURY FROM EXCESS OR DEFICIENCY OF MICROELEMENTS

Boron Deficiency

Apple Trees

Internal corking caused by low boron levels in apple was first reported in 1919, although the cause was not recognized. It was reported in 1940 that borax application was an effective treatment. Other physical injuries caused by boron deficiency include shoot dieback, inhibition of leaf bud germination, rosette-shaped shoot tips, and marginal chlorosis in young leaves. Symptoms tend to be more severe in young trees (Table 4 and Table 5).

Toxicity from Excess Boron

Apple Trees

In general, boron levels in the soil of Korean orchards are not high enough to cause boron toxicity. However, boron toxicity can occur if growers apply too much boron fertilizer.

Leaves of apple trees growing in soil with a high boron content tend to bend backwards. The leaf veins are yellow, and there is chlorosis of the leaves. The level of boron in leaves showing toxicity symptoms is 231 - 342 mg/L.

There is often necrosis of the epidermis in shoots of the scion above the grafted area. In fruit, there is often internal browning during storage. Fruit are small in size, and there is increased preharvest fruit drop and macrophoma rot.

Pear Tree

Symptoms of boron toxicity in pear trees include shoot dieback, leaf chlorosis, defoliation and fruit cracking. Leaves at the ends of shoots tend to bend backward. In orchards where trees show such symptoms, the boron level of both plants and soil is much higher than in other orchards (Table 6).

Manganese Toxicity

Apple Trees

'Bark necrosis' is a common physiological disorder in apple orchards in Korea. Small protrusions build up on young shoots. The cambial tissue under the bark browns and blisters, while the bark on young twigs and branches cracks and peels. Experiments found that these symptoms were caused by manganese toxicity. This injury is affected by both the kind of rootstock and the calcium level of the tree. For example, manganese absorption was markedly higher in *Malus sieboldii*, compared to that of other rootstock. The higher the calcium level, the lower the extent of the injury.

Persimmon Trees

Manganese toxicity in persimmon does not produce symptoms in the leaves or shoots, but the fruit have green spots when they reach maturity. This damages the appearance, and reduces the quality and price of fruit.

CONCLUSION

More than half of the orchards in Korea are in slopeland areas, with acid soils. Most orchard soils have a low boron and a high manganese content, with optimal levels of zinc and iron. Symptoms of boron deficiency and manganese toxicity were observed in the 1960s and 1970s, while boron toxicity from over-fertilization has occurred since the 1980s.

Low boron levels in soil cause shoot dieback, inhibition of leaf bud germination, rosette-shaped shoot tips, and marginal chlorisis in young leaves. In fruits, internal browning and malformation are observed, resulting in poor fruit quality. Boron toxicity causes leaves to bend backward and leaf chlorosis. Toxicity also causes internal browning of fruit, small fruit size in apple, and fruit cracking and early fruit drop in pear. Disorders due to manganese are mainly related to toxicity, especially in apple trees. The extent of toxicity varies with the soil pH, the rootstock and the cultivar, and is also affected by interaction with other mineral nutrients such as calcium in the soil. Internal bark necrosis is a typical toxicity symptom in apple, as is green spot in persimmon fruit. Since these disorders involving minor nutrients vary according to the type of fruit and the cultivar, it is necessary to establish estimated critical levels each time a new variety or rootstock is introduced.

Table 4. Comparison of soil acidity and boron content of young apple trees with and without dieback of shoots

Orchard	pH	Available boron (mg/L)
Damaged orchard A	4.8	0.13
Damaged orchard B	6.1	0.20
Normal orchard	5.2	0.46

Source: Kim and Byun 1967

Table 5. Effect of boron application on rosette shape, leaf chlorosis, and boron content on leaves and shoots of apple trees.

Borax treatment	Symptom		Boron content (mg/L)	
	Rosette	Chlorosis	Leaves	Twigs
10 g/tree	-	-	25.5	14.0
20 g/tree	-	-	20.0	10.0
30 g/tree	-	-	27.5	13.0
Untreated	+·	+	8.0	7.5

-: No. symptoms, +: Slight symptoms, ++: Severely symptoms
Source: Kim and Byun 1969

Table 6. Comparison of boron content (mg/L) in soil, shoot bark, and leaves in normal pear orchards, and those showing symptoms of boron toxicity

Orchard	Soil	Bark of shoots	Leaves
Boron toxicity	0.56	120**	155**
Normal	0.14	39	45

** Significant at 1%.
Source: Choi *et al.* 1986.

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