The role of micronutrients in avocado cultivation

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Introduction

Chemical elements are referred to as "micronutrients", or "trace elements", because their concentrations in plants are less than 100 mg/kg (ppm) on dry matter basis. Actually, many of these elements are present at concentrations much lower than this. By contrast, macronutrients like nitrogen and potassium, are present in plants at concentrations around 1–3%, i.e. ~1000-fold higher. Most micronutrients of plant/human/animal health and environmental significance are metals, like cobalt, copper, iron, manganese, molybdenum, nickel, and zinc. Other important ones are nonmetals, like arsenic, boron, chlorine, molybdenum, selenium and silicon. Trace elements occur naturally in soils. The major natural sources include soil weathering, erosion and deposition of wind-blown particles, volcanic eruptions, forest fires and biogenic sources. Low soil concentrations of essential micronutrients can result in their inadequate supply to plants, affecting plant growth and development, which ultimately can cause deficiency disorders, further up the food chain, and this is when specific fertilizers should be included in the mineral nutrition scheme of the deprived crops. Regardless of their biological essentiality, trace elements become toxic when taken up in excessive amounts.

A good starting point for a good fertiliser program is the crop removal figures.

Remocion de micronutrientes en grams por 10 MT (metric ton) de fruta de aguacate, de la variedad '*Hass*'

Lugar	Boro (B)	Cinc (Zn)	Cobre (Cu)	Hierro (Fe)	Manganeso (Mn)	Molibdeno (Mo)	Nickel (Ni)
California	192 ; 993	67 ; 386	29 ; 144	45 ; 117	12 ; 22	0	36
Nayarit (Mx)	40	40					
Michoacan (Mx)	71–80	38–48					
New Zealand	88	88	22	198	44		

The above table shows clearly that the micronutrients, removed by the fruit at highest amounts are boron, zinc, copper and iron. This does not reduce the importance of the other ones, because any deficiency can provoke a serious damage. Naturally, every micronutrient should be returned to the soil or directly- to the tree at the amount that is exported by the fruit, plus and appropriate efficiency coefficient. It should also be reminded that no nutrient can replace another one, so, a high level of one element in the soil, or even- in the plant, cannot compensate for the deficiency of another element.

Another helpful tool for the grower, is leaf analysis, performed according to a strict standard as follows.

Elemento	Deficiente	Bajo	Normal	Alto	Exceso
Boro B (ppm)	<14 ; 10-20	15-29	30-50 ; 20-100	51-99	>100 ; >100
Zinc Zn (ppm)	<20 ; 1-20	21-24	25-100 ; 30-150	101-299	>300 ; >300
Cloro Cl (%)	N.A	N.A	0,07-0,23	0,24	>0,25
Cobre Cu (ppm)	<3,00 ; 2-3	4	5-15 ; 5-15	16-24	>25 ; >25
Hierro Fe (ppm)	<40 ; 20-40	41-49	50-150 ; 50-200	151-249	>250
Manganeso Mn (ppm)	<19 ; 10-15	20-49	50-250 ; 30-500	251-749	>750 ; 1.000
Molibdeno Mo (ppm)	< 0,01 ; < 0,01	0,02-0,04	0,05-1,00 ; 0,05-0,01	N.A.	N.A.

The main functions and challenges of the aforementioned micronutrients

Boron (B)

Avocado trees probably use more boron than any other crop, mainly for good flower formation and fruit-set. Boron is essential for Ca transport within the tree, and for normal development of growing shoot tips (apical meristems), especially during pollination, as it enhances pollen-tube growth, which directly increases fruit-set rate.

B is also essential for normal branching, normal formation of flowers, fruits and roots, synthesis of nucleic acids, and metabolism of carbohydrates. Its weak negative charge makes it very sensitive to leaching, hence- to low use efficiency. Higher use efficiency is obtained if the soil is rich in organic matter, or if the boron is applied complexed with humic acid. Sugar-borate complex is mobile in the tree's xylem, but its phloem mobility is limited.

Zinc

Zinc is a key structural and catalytic component of a large number of proteins, as cofactor for over 100 specific enzymes, transcription factors and protein interaction domains, and nucleic acids synthesis. Zinc is essential for the transformation of carbohydrates and regulation of sugar consumption in the plant. It is indispensable for producing the auxin IAA and Gibberellic acid. Therefore, Zn deficiency causes growth retardation, and 'little-leaf' and rosette growth pattern. Zn- root availability is highest at soil pH of 5-7.5, and much lower on both sides of this range. Its availability is negatively related soil to phosphorus availability. Zn deficiency symptoms: Leaves' mottled interveinal chlorosis, they are smaller than normal, and have a rosette growth pattern. Also, small rounded fruits.

Copper

In most of the Cu functions as a plant nutrient, it is bound to enzymes, which catalyze redox reactions in photosynthesis, respiration, C- and N- metabolism, and protection against oxidative stress. It forms highly stable complexes, and participates in electron transfer reactions, in which it continuously changes its valence between +2 and +1. Cu-enzymes react in living cells directly with molecular oxygen. More than 98% of the Cu in plants is present in complexed forms in cells' cytoplasm. Cu- root availability is highest at soil pH of 5-7.5, and much lower on both sides of this range. Its availability is also positively related to soil organic matter. Cu deficiency symptoms: Older leaves have a dull appearance. Shoot tips have multiple bud formation. New leaves abort and dry up.

Iron (Fe)

Iron is a constituent of two major protein groups, namely, the heme-, and the Fe-S- proteins. These macromolecules are involved in respiratory and photosynthetic activity, essential for numerous plant functions. A central one is, of course, chlorophyll production and functioning, but other important functions are redox reactions, dealing with respiration, energy transfer and metabolic processes, within the plant. Several heme proteins act as cofactors of the cytochromes, involved in respiratory reactions. Other heme proteins include catalase, and peroxidase, converting hydrogen peroxide into water and O_2. Fe-S proteins have a strong involvement with the light dependent reactions of photosynthesis. Ferredoxin, that contains iron atoms, is the end product of photosystem I, and it transfers electrons to a number of acceptors. Fe- root availability is highest at soil pH of 4–7, and much lower above 7. Most prevalent avocado Fe deficiency symptom is interveinal chlorosis of young, fully expanded leaves.

Manganese (Mn)

Mn functions mostly in activating many enzymatic systems, and is also a constituent of certain enzymes. It participates in a variety of redox processes, such as enzymes, involved in breakdown of carbohydrates, and as a cofactor of enzymes reducing nitrate to nitrite. It also plays important roles in photosynthesis, pollen germination, and growth of the pollen tube. Mn is rather immobile within the active transport phloem system. So, its deficiency symptoms will firstly appear on younger leaves. Manganese root availability is highest at soil pH of 5-7.3, and much lower on both sides of this range. Most prevalent avocado Mn deficiency symptom is interveinal chlorosis of young, fully expanded leaf.

Molybdenum (Mo)

Molybdenum is vital in the avocado tree for the reduction of nitrates, on their way to protein synthesis. Mo- root availability is highest at soil pH above 6.5, and much lower- below 6.5.

Chlorine (Cl)

Is required in photosystem II, at concentrations of 200-400 ppm in dry matter. But, as it is very common in soil and irrigation water, it provokes avocado yield loss of 12% for every 35.5 ppm Cl^- in the irrigation water.

Literature cited

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