Macronutrients and micronutrients deficiency symptoms in mango

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ABSTRACT

Nutrients deficiency symptoms bear a direct relationship with the plant biological functions, starting with modifications at the biochemical level and then evolving to the sub cellular, cellular, levels and, at the last stage, to the tissue level, this being the only instance when symptoms become visible. Each nutrient is characterized by singular symptoms so that it is possible, by visual examination of the plant, to evaluate the orchard nutritional status. Although reaching its highest efficiency when applied to perennial plants, visual examination is still considered as a complement to soil and plant chemical analyses.

Kew words: plant nutrition, leaf analysis, nutritional disorder, mango

1. INTRODUCTION

Visualizing nutrients deficiency symptoms permits improving fertilization programs, so as to apply, via soil or foliar, the adequate amounts of fertilizers to the plants. So, the plants nutritional status diagnose methods (soil analysis, foliar analysis, and visual diagnose) should be applied in conjunction.

In mango, the visual examination of the plants is an important additional tool since it permits modifications in the fertilization program during the same cropping year. Thus it becomes possible to interfere in a situation of nutritional disorders in a short period of time so as to guarantee fruits of better quality (Prado, 2004).

According to details in the book chapter "Mineral nutrition and fertilization of mango crop", the symptoms exhibited by a plant have a direct relationship with the functions the mineral plays in the plant metabolism. So after the occurrence of the biological events, the symptoms will be related to the mineral element causing the nutritional disorder and this is linked to its functions and mobility in the plant.

Using visual examination requires a high level of certainty that the problem under analysis in the field is ascribable to nutrient deficiency - or excess - since insects attack and diseases problems are capable of resulting in symptoms difficult to differentiate from those caused by the nutritional disorder. The symptoms resulting from nutrients deficiency have the following characteristics : **Dispersion** - the nutritional problem usually has a homogeneous distribution in the field. The symptoms caused by insects or diseases most of the times are irregularly distributed. **Symmetry** – in a pair of leaves, the nutritional disorder is verified in both leaves. **Gradient –** in a branch or in a plant, the symptoms distribution seem to obey a pattern by which they either gradually increase or decrease in intensity from the older to the younger leaves (Prado, 2008).

So, the deficiency/excess symptoms as detected by visual examination may vary with the crop species. Usually, the deficiency symptoms are found in old leaves when the deficient elements have high mobility in the plant tissues or in young leaves, when the elements are of low mobility in the plant tissues. These visual symptoms may also be seen in the roots.

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The objective of this chapter is to offer the reader a detailed account of the visual symptoms in mango plants resulting from macro and micronutrients deficiencies.

2.MACRONUTRIENTS DEFICIENCIES

Mango plants nutrients demand, expressed as the accumulated amounts of the elements found in different plant organs, vary according to factors such as genotype, soil, and the expected productivity level. Usually the highest demanded macronutrients, depending on the production system, are N and K, followed by Ca, Mg, P, and S. The micronutrients are Cl, Fe, Mn, Zn, Cu, B, and Mo. So, if the absorption of these elements by the plants meets with any impediment, due to their being deficient in the soil or to inadequate fertilization practice, deficiency symptoms are likely to show. These symptoms will be described in the next section. Symptoms caused by Cl and Mo deficiencies will not be considered due to insufficient information in the literature and also because mango plants have never been described as showing symptoms of deficiency of these elements.

2.1 - Nitrogen

Nitrogen deficiency symptoms are reported to be initially found in older leaves as a chlorosis or yellowing, slow growth and lack of vigor. Severe nitrogen deficiency may cause a complete yellowing of the leaves, their dropping from the plants and the death of the terminal branches (Smith and Scudder, 1951).
Nitrogen deficiency causes retarded growth, lower vegetative growth, chlorophyll loss, generalized yellowing and reduced fruit production (Jacob and Uexkull, 1958; Geus, 1964; Childers, 1966). On the other hand, plants with high concentrations of N show dark green leaves, excessive vegetative growth, the plants show difficulty in changing from the vegetative into the reproductive stage, with reduction in fruit productivity and quality. High nitrogen contents are, in several mango varieties, associated with physiological disorders such as jelly seeds and internal breakdown (Cracknell Torres et al., 2004; Silva et al., 2008). These plants are usually more susceptible to diseases. Caldas (2009) found that increasing doses of nitrogenous fertilizer brought about a reduction in the plant contents of P and K during the flowering period and that this led to reduced fruit production.

2.2 – Phosphorus

Phosphorus deficiency symptoms are rarely observed in mango plants. Since P is a mobile element in the plant, the symptoms are first observed in older leaves. The symptoms are : necrosis in the leaf marginal tissues, leaves with brown dots, bud necrosis, premature death of the branches (Smith and Scudder, 1951). Mango plants under P deficiency conditions present reduced root development, reduced capacity of water and nutrients absorption, retarded onset and maturation of fruits which show a coarse texture (Childers, 1966)
Although the mango plant requires low levels of P in comparison with the amounts of N and K demanded, it is advisable to include this element in the fertilizer formula because,

under tropical conditions, P is usually strongly fixed in the soil, sometimes the point in which the plants develop P deficiency symptoms (Silva, 1997).

2.3 – Potassium

Potassium deficiency symptoms start in older leaves which are seen as yellowish and irregularly distributed punctuations. The symptomatic leaves are thinner and of smaller size than the normal ones. They drop from the plants only when they are completely dead (Childers, 1966; Koo, 1968). Potassium in excess may cause an unbalance in Ca and Mg levels and also cause the margins and apexes of green leaves to show a blighted aspect. When adequately administered, potassium improves fruit quality, particularly fruit color, fragrance, size, and shelf life (Samra and Arora, 1997).

2.4 – Calcium

Calcium deficiency is first seen in young developing tissues due to its low mobility in plant tissues. Calcium deficient plants are short and more chlorotic than the normal ones. Under severe calcium deficiency situations, leaves show darkened margins, except at the basis and the apex; later on, these leaves become yellow and fall (Kumar and Nauriyal, 1977). The symptoms of physiological disorder in mango seem to be associated with the premature maturing of the fruits and with the degeneration of cellular tissues (Burdon et al., 1991, 1992). The internal collapsing of leaf tissues seems to be associated with low calcium levels in the leaves (Cracknell Torres et al., 2004; Assis et al., 2004; Silva et al., 2008). So, the main beneficial effects of calcium is attributed to its being capable of increasing fruit tissues consistency during maturation and this results in fruits of better quality.

2.5 - Magnesium

Reduced plant growth and the premature falling of leaves are caused by magnesium deficiency. In addition to that, below the central part of the leaf, a green wedge-shaped chlorotic area is visible in a few leaves.
Magnesium deficiency causes the development of a dark green inverted V shaped area by the intrusion of a bronzed chlorosis in the leaf margins, reduction in plant development, and premature leaf dropping (Smith and Scudder, 1951; Childers, 1966; Kumar and Nauryial, 1977). Magnesium deficiency usually occurs in sandy soils or highly lixiviated soils due to their low cation exchange capacity or due to high doses of calcium and potassium (Silva et al., 2004; Pinto, 2008).

2.6 - Sulfur

Sulfur is of low mobility in plant tissues so that the deficiency symptoms of this element are first seen in young leaves. In other species, the sulfur deficiency symptoms are similar to those of nitrogen, although they show a better distribution between young and old leaves. The symptoms are seen first in the young tissues since sulfur is not redistributed to young leaves (Marschner, 1995).
Sulfur deficiency symptoms in agricultural crops are seldomly observed since the application of mineral and organic fertilizers to the soil is usually sufficient to guarantee the needed levels of sulfur to the plants. Sometimes, even pesticides are capable of providing cultivated plants with the needed S levels (Silva et al., 2004). In case

deficiency occurs, the young leaves show necrotic spots over a green background; premature defoliation is also a frequently observed symptom (Smith and Scudder, 1951; Kumar and Nauryial, 1977; Silva, 1997).

3.MICRONUTRIENTS DEFICIENCIES

3.1 - Boron

Boron deficiency symptoms occur first in the young parts of the plant while toxicity is seen at the extremities of the older leaves.
Boron deficiency causes leaf growth reduction and the intermediate leaves of the vegetative flux show a suede brown color. The apical bud usually dies, excessive lateral budding is common, resulting in a cluster of secondary branches (Agarwala et al., 1988). The panicles show a reduced size and bear a smaller number of hermaphrodite flowers and this leads to a lower number of fruits (Singh and Dhillon, 1987).
Rosseto et al. (2000) reported to have observed that the fruits of the mango variety 'Van Dike', under conditions of boron deficiency, occur in a small number and these fruits are of a brown color. This brown color was not observed in fruits of the 'Hadden 2H' variety although they were also produced in small numbers (Rosseto et al., 2000).
In mango varieties such as 'Tommy Atkins' and 'Van Dike' fruits with collapsed tissues are frequently found. Some of these symptoms were associated to boron deficiency, and these symptoms have been designated as 'internal fruit necrosis" (Ram and Sirohi, 1989). These symptoms start by a dark green color located at the fruit apex which evolve with time to give the whole fruit a dark brown color. The internal tissues of the fruit show signs of disintegration and become of a dark brown color what, sometimes, is followed by the oozing of a gummy exudation.
The adequate dose of boron is important since the difference between deficiency and excess is very small (Silva et al., 2004). Boron toxicity causes leaves to become with blighted margins and fall rather easily, this being possible to occur between vegetative fluxes following the application of excessive doses of boron fertilizers. Toxicity symptoms may be attenuated by lixiviating soil fertilizers, increasing soil pH by the application of lime or nitrogenous fertilizers although these measures may affect productivity (Bally, 2009).

3.2 - Copper

Usually copper deficiency symptoms are seen in young plants, or in buds of adult plants, which were submitted to high doses of nitrogenous fertilizers. In copper deficient plants the development of S-shaped long and tender branches and downward curved leaves have been observed. In branches, the eruption of blisters which sometimes exudates a gummy substance is one of the symptoms of copper deficiency. The terminal branches may undergo progressive death mainly those S-shaped that developed in the preceding year (Quaggio and Piza Jr., 2001). On the other hand copper is seldomly deficient in mango plants not only because mango demand for copper is low but also because several of the fungicides used in diseases control have copper in their formula.

3.3 - Iron

Iron deficiency is initially perceived in young leaves where a typical chlorosis develops forming a green reticulate following the framework of the leaf nervures which is highlighted by the yellowish leaf blade. Severely affected leaves are of a light yellow showing none to very few green nervures. Branch drying may occur under very severe deficiency conditions.
Iron deficiency is related to the cultivation in soils originated from lime rich substrates as has been found in several parts of the world or in acidic soils with very high manganese content. In Brazil, with the exception of some soils in the Northeast region, iron deficiency is very unlikely. Sometimes in poorly drained soils excessive doses of manganese may cause iron to become unavailable to plants. In guava, Silva et al. (2004) reported to have observed iron deficiency when high doses of P were applied to the soil.

3.4 - Manganese

Manganese deficiency may be the cause of reduced growth in mango plants. The first symptoms are seen in young leaves. A yellowish green color develops in the leaf background with the nervures keeping their green color – in the manganese case, the green nervures are a little wider than those of the iron case. Under severe manganese deficiency, there develops a generalized yellowing of the young leaves followed by a necrosis of the leaf blade tip (Agarwala et al., 1988). Manganese availability in the soil is reduced by liming and high doses of P (Silva et al., 2004).

3.5 - Zinc

The main zinc deficiency symptom is verified in the leaves which are small, narrow, curved, thick and inflexible. Between nervures a chlorosis of a speckled brown is sometimes seen. The branches produce few secondary branches and the internodes are of short length and this results in small plants (Ruhele and Ledin, 1955; Geus, 1964).
Floral malformation or and vegetative malformation or "witch broom" may, in part, be associated with zinc deficiency since the plants emit small, irregular, multiple and distorted panicles (Silva et al., 2004). Zinc deficiency may be more severe in rich in lime soils or in soils which received high doses of lime or of phosphorous fertilizers.

4. NUTRITIONAL DISORDER

One of the most important problems for growing commercial mango orchards are the nutritional disorders. These disorders are thought to be caused mainly by nutritional unbalances. Since mango plants of different genotypes, growing under the same cultural practices in the same environment, show different responses to nutrient deficiencies, the genetic influence is also to be included among the most important factors. Mango varieties whose fruits are of a high level of fibrousness, such as 'Espada' and 'Coquinho', seldomly show signs of nutritional disorder whereas genetically improved varieties such as 'Tommy Atkins', 'Kent', 'Irwin', and 'Keitt' are highly susceptible to nutritional deficiencies (Evangelista, 1992).
Fruits internal collapse is the most important and frequent problem at the beginning of fruit maturation, at after-harvest, and during commercialization (Prado, 2004). This type of problem causes the fruit flesh to become soft, losing its natural consistency, this resulting in fruits partially or totally unfit for consumption. Fruit flesh softening is the

most easily visible symptom and may be accompanied by fractures in the seed, rotten areas in the bark, and warts on the bark (Prado, 2004).
Due to these observations some authors concluded that the most important factor determining nutritional disorder is the relation N/Ca. The highest incidences of mango fruit internal collapse are found in orchards which received high doses of N (McKenzie, 1994; Silva et al., 2004). Assis et al. (2004) evaluated the effect of nutritional equilibrium on the incidence of physiological disorders in mango plants of the variety 'Tommy Atkins' growing in the San Francisco valley and found out that high levels of Ca and Mg as well as low relations N/Ca and K/Ca in the fruit flesh or coat were enough to prevent physiological disorders. According to Assis et al. (2004) the importance of the relations N/Ca, K/Ca, and K/Mg in the development of physiological disorders is evidenced by the roles played by those elements in the plant physiology and by quickness with which these elements are absorbed and translocated in the plant tissues.

5.FINAL CONSIDERATIONS

As a general rule, nutrient deficiencies affect physiological events as well as fruit production and quality. Under some circumstances, the excessive presence of a nutrient may result in reducing the availability of other nutrients and this usually is worse than the deficiency itself of that nutrient. The regular evaluation of the presence of the nutrient in the plant tissues by means of chemical analyses associated with visually examining the plants are simple and quick procedures to have an idea of the orchard nutritional status, making possible optimizing the management of nutrients to be furnished to the plants.

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