

Oligo- Element concentration of the Avocado ' Fuerte ' in Morocco - results leaf analysis

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Abstract:
The fertilization operation of avocado trees must take into account the chemical composition of environmental soil and chemical elements of plant leaves. However, in Morocco, farmers don't know well cultural techniques of avocado cultivation. Indeed most of them rely on the qualitative and quantitative fertilization applied to other types of trees. In this study, we assess the nutritional status of the Avocado variety called "fuerte" with some chemical elements. For this purpose we use leaf technical analysis to measure concentrations of these elements in avocado so that we can determine the quantity of every element needed by the tree. The results show that the different orchards studied did not suffer from the same deficits or excesses of the chemical elements studied. So, the application of this technique is so interesting for the culture of avocado and the respect for the environment.
Keywords: Avocado, fertilization, leaf analysis, 'Fuerte' variety, Morocco

INTRODUCTION

Avocado is of mexican-Guatemalan origin (Smith, 1969).This finding is consistent with that of Hodgson (1950) who reported that in 1842, the date of America's discovery, Europeans noted the presence of avocado trees in most regions from northern Mexico to Peru. During the XVI and XVII centuries and from this origin area, the Spanish spread the avocado cultivation trees in Venezuela, Caribbean and Chile. Later, the avocado made its first appearance in Hawaii (in 1850) (Hodgson, 1950), in Malaysia (in 1900), in Philippines (Labourne, 1934) in Brazil (in 1925). In Mediterranean area, the diffusion is higher, except Algeria where Hardy introduced avocado in 1843. In Morocco, this tree has become known only since 1931 (Vogel, 1961). Schultz (1915) and Church (1921) were the first to have studied chemical composition (Table 1), vitamins composition and nutritional value of avocado (Table 2). In Morocco, the culture of the avocado was introduced in 1931 and currently covers an area of approximately 1,920 ha spread over several regions (Fig. 1): 37% of the Gharb plain, the Rabat / Sale 28% Khemisset 13%, 13% Loukkos and Ben Slimane 3% (Ministry of Agriculture and Maritime Fishing). Ecological conditions preferred by this plant are grouped at these areas: light soil (especially sandy) and a climate that is not neither too cold in winter nor too hot in summer.
Moreover, during the agricultural year 2013/2014, the Moroccan production of the avocado is on the order of 32230 tons and the average yield of 11.14 t / ha. The productive area of 2893 ha, an average yield of 11.14 t/ha with a wide variation from one region to another (Table 3). Constraints that reduce production are numerous. The cold, frost, age of plantations and lack of mastery of the technical management of the avocado, including ignorance of good conditions for fertilization of the plant are the main obstacles.
So, in all Moroccan orchards the fertilization of avocado is done without resorting to modern technology to know, with good precision, which minerals needed for the tree. Always the procedure leads to misuse of these fertilizers substances. Thus, in this work, we determine the real needs of avocado grown in Morocco by applying the technique of foliar analysis in thirteen plantations of 'Fuerte' variety.

MATERIAL AND METHODS

The presence of favourable climate and the sandy soil in the Gharb region rabat / Sale and the Loukkos zone (Fig. 1) explains 78% of the why the Moroccan avocado culture is located in these regions. For this study we have chosen thirteen orchards situated in this area. Three of them are situated near Kenitra city, one near Moulay Bouslhame (Plaine du Gharb), two near the Sidi Allal Tazi city (Gharb area), two near Ouamra village (Loukkos Zone), one near Larache city. These thirteen orchards are distributed on the coast between Rabat and Tangier along 450 km of coastal road. In each orchard, we chose ten well-distributed plants in operation. Of each selected tree, four leaves with different orientations and about the same age (4-6 months) are collected in the spring. The leaves collected immediately introduced into clean plastic bags, then dried and ground in the Laboratory of Plant Biodiversity, Faculty of Science, University Ibn Tofail, Kenitra (Morocco). Concentrations of nine chemical elements were assessed in the Laboratory of Tropical Fruits, the Mayora, Malaga, Spain; namely nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) calcium (Ca), boron (B), copper (Cu), Zinc (Zn) and manganese (Mn). The leaves were analyzed in the fall.

RESULTS AND DISCUSSION

I- The foliar concentrations of chemical elements in the studied orchads and the norms of the favourable values to the Development of the cultivar 'Fuerte'

1 - Nitrogen (N)

In most of the farms surveyed, it appears that, vis-à-vis the nitrogen, there is not much difference between the amount used by the crop and inputs of nitrogen fertilization (Table 4). Thus, it is of great importance to consider, in a future fertilization, the existing balance. Note also that the amount of nitrogen in the culture medium greatly influences the growth of avocado (Chia and *al*., 1988). It interferes with the determination of nodes and the ramification of the branches (Lobit and *al*., 2007) and determines the resistance degree of avocado tree to the low temperatures (Lahav and *al*., 1987). Another study shows that Nitrogen is one of the constituents of vegetables organic compounds. Involved in cell multiplication, it is considered a growth factor necessary for the formation of amino acids, proteins, enzymes (Jiménez, P.G. et al., 2010).

However, excessive nitrogen fertilization may reduce the fruiting and stimulate the vegetative growth of avocado (Walali & Skiredj, 2003; Embleton and *al*., 1968). It can also delay senescence of old leaves and causes a decrease in the translocation of copper from these leaves to younger leaves. The symptoms of nitrogen deficiency are expressed by a limited growth, the leaves are small, and fall prematurely. The yield may decrease considerably (Malo, 1967).

Moreover, it is impossible to understand the relationship between the content of leaves nitrogen and performance of counsel, without taking into account the carbohydrate reserves of the tree (Lahav & Kadman, 1980).

2 - Phosphorus (P)

For this element, all orchards studied had levels higher than those required by the tree, Phosphorus is an important nutrient because it forms the connection with the substrate in the energy storage, for the structural integrity of the plant (table 4). Phosphorus is a basic compound present in the energy called ATP. It is an integral part of the compounds of vital importance in plant cells , including those involved in the breathing process . (Olivares , C., 2013).

Symptoms of phosphorus deficiency are expressed as a decrease in vegetative growth, leaves are round, small and drop early, so the branches die. Moreover, phosphorus is an essential element for growth and normal development of plants (Street & Kidder, 1989). However, excess in phosphorus and nitrogen pollutes the quality of surface water and groundwater (Taoufik and *al*., 2005).

3 - Potassium (K)

The potassium concentrations were favourable to a good development of the cultivated variety of avocado trees (table 4). This chemical element is necessary for proper development of avocado (Lahav & Kadman, 1980). Note that the phosphorus and potassium requirements also vary proportionally with the tree age, with a ratio of 2: 1 . 4 for N, P and K , respectively (Jerry, C. et al., 2011)

Potassium use in plant nutrition is not known for perfection ; but however, it is believed that potassium acts in the metabolic functions , cell growth and division in young tissues (Barquera, M. et al., 2014).

Indeed, a potassium deficiency causes a formation of small leaves and necrotic. According to these authors, the deficiency symptoms seem to occur in trees with more than 8 years, trees grown in sand and that receives no potassium fertilizer. In autumn, necrotic spots appear on older leaves, twigs become very thin and some dieback occurrs, the leaves are small and narrow red-brown (Furr and *al*., 1946; Charpentier and *al.*, 1967)

The degree of absorption of potassium by the avocado is affected by the richness of the soil exchangeable cation concentrations and foliar potassium is growing with increasing soil concentration of magnesium and calcium decreases (Haas, 1949). The potassium requirement of plants varies with soil pH, its ability to exchange and its richness in organic matter (Oppenheimer & Kadman, 1962).

However, a relationship between leaf potassium content and soil type may exist: on soils rich in limestone, this content is much lower than on other soils (Oppenheimer & Kadman, 1976). Similarly, it seems that high levels of this chemical element allow certain varieties of avocado to be more tolerant to frozen conditions and cold (Lahav and *al.*, 1976).

4 - Calcium (Ca)

In all orchards surveyed, the noted levels of calcium were favourable to a good development of the variety of cultivated avocado (table 4). Note that the presence of calcium in the cell is essential for the plant development (Marme 1983; Marme & Dieter, 1983, Hepler & Wayne, 1985; Poovalah, 1985). It plays a role during the main stages of the life of the plant. It is involved in cell division and plays a major role in maintaining the integrity of the membrane.

Calcium deficiency also reduces the amount of protein produced by the plant and makes it more susceptible to pathogens and facilitates the softening of the fruit after storage (Tingw & Young, 1974; Wills & Tirmazi, 1982).

Visually this deficiency is manifested by leaves being torn from limbs spontaneously; the fruit, due to poor physiological functioning may be affected by certain diseases such as necrosis.
Moreover, the deficiency or the excess of calcium in the leaves can disrupt the absorption of other chemical elements, by inhibiting the absorption of iron and manganese, limestone causes iron chlorosis of excess in the plant resulting in yellowing and worse necrosis of foliage extreme (Lahav & Kadman, 1980). In another work, the maintenance of high levels of Ca, in the soil would reduce the degree of roots rot (Lahav & Kadman, 1980).

5 - Magnesium (Mg)
Exception the orchard No 9 which has presented a higher concentration of magnesium compared to needed by the cultivated avocado, all the studied fields have showed good contents of magnesium (table 4). Usually, the concentrations of magnesium and calcium have the high levels in the leaves, roots and bark (Witney and *al*., 1990). However, toxicity characterized by leaf blight and plant death, is noted when the concentration of magnesium is excessive compared to that of calcium (Brusca and *al*., 1960). The concentration of magnesium influences the absorption of potassium by avocado tree (Haas, 1949).
Furthermore, by its significant presence in the chlorophyll, the magnesium is involved in the formation and the setting aside of sugars, carbohydrates and vitamins (Elalaoui, 2007). This chemical element is also very important in many vital functions in the plant of Magnesium deficiency leads to the chlorosis plants with a green-yellow color between the veins of old leaves, sometimes followed by necrosis (Furr and *al*., 1946; Robinson, 1961). The leaves often remain green on the periphery. The ends and edges are partly curved upward

6 - Copper (Cu)
In all the orchards the illustrated levels were low. The orchards No. 1, 6, 8, 9 and 10 have shown a deficit of copper (table 4). However, in the plant copper is involved in the process of photosynthesis and the formation of lignin. The bulk of copper is localized in chloroplasts. Also, this chemical element has an involvement in the process of biological fixation of nitrogen and in regulating the absorption of manganese. Elalaoui (2007) adds that a copper deficiency accelerates the absorption of manganese; thus leading to the toxicity of the plant. It can also cause the dieback of avocado tree (Ruehl, 1940) and causes the formation of thin yellow leaves (Furr et *al*., 1946). This phenomenon mainly occurs in acid soils.
Moreover, it is in the organic soils with a pH greater than 7 where the deficiency in copper has mostly appeared. This phenomenon can be explained by the fact that copper is more rapidly adsorbed by soil organic matter than other elements.
In addition, intense nitrogen fertilization can delay senescence of older leaves leading to a decrease in the translocation of copper from these leaves to younger ones. This leads that are symptoms of copper deficiency which appear first on young leaves, because of the low mobility of copper.
Moreover, significant quantities of copper can accumulate on the surface of the roots of the avocado tree after spraying fungicides (Malo, 1977).

7 - Zinc (Zn)
The orchard No.1 has showed a deficiency of zinc; the other orchards have the normal concentrations of zinc (table 4). The application of Zn in soil will increase production of fruits / tree , producing large fruits (170-266 g) reduce fruit small sizes and round (Salazar- Garcia.S et al , 2014). Note that Zinc is essential to the plant metabolism. It is the activator of the enzyme carbonic anhydrase, an enzyme essential for the use of carbonic acid, of several other metal-enzymes and of certain proteases and peptidases (Elalaoui, 2007). It regulates the plant's growth and increases plant resistance to fungal diseases. Thus, a plant zinc deficiency manifests itself negatively on fruit size and embryonic development. The leaves become arranged in rosettes at the end of new shoots, of narrow, small size and drop prematurely. The fruit may be small and spherical rather than pear-shaped fruit (Wallihan and *al*., 1958).
Moreover, the pH is considered as a most important factor of the zinc deficiency: a pH of 6.5 to 5.3 increases the absorption of zinc by 50%. In addition, according to Lahav and Kadman (1980) deficiency is common in avocado and it is particularly difficult to avoid in soils with high pH.

8 - Manganese (Mn)
None of the orchards studied presented an excess or deficiency of manganese. All noted values which allow a good development of the avocado (table 4).
Furthermore, manganese is an important activator of redox enzymes, the decarboxylation and the transfer of the radicals and its deficiency affects the formation of chloroplasts, the intensity of photosynthesis and the activity of nitrate reductase (ELalaoui, 2007). It is also involved in regulating the absorption of water by the plant.
The dependence of absorption between the zinc and the manganese was signalled by Haas (1939). Similarly, the absorption of manganese is affected by some pH values. In a soil rich in organic matter and a neutral or alkaline pH, the risk of an occurrence of manganese deficiency is important,

Moreover, in fruit trees the symptoms manifested by yellow spots on the leaves, but the veins remain green (Wallihan & Embleton, 1958). Later, necrosis which appear occasionally perforate the leaf (Furr and *al*., 1946).

9 - Boron (B)

In all orchards the shown boron concentrations were higher than those required by the plant (table 4). But, as it was pointed by Lahav and Kadman (1980), avocado trees are generally much more resistant to an excess of boron than are citrus. In fruits, the required elements are mainly K , N, P and B, (Bárcenas et al., 2003 , quoted by –Garcia, S. Salazar , 2012).

Further, we note that in a plant the role of boron is multiple (Whiley and *al.*, 1996). It allows the migration and the use of carbohydrates, the formation of ribosomes, the protein synthesis and the meristematic growth and the absorption of potassium, phosphorus, magnesium and other cations. It promotes further pollination but combined with high levels of urea the effect becomes negative (Lahav & Kadman, 1980). A boron deficiency can cause infertility or the malformation of the reproductive tissues, thickening of terminal buds in the case of a severe impairment, and young leaves are distorted, wrinkled, thick bluish green color and lower the level of concentration of Foliar calcium; sometimes irregular chlorosis occurs between the veins. In contrast an excess of boron leads to the formation of the burn spots on the leaves (Harkness, 1959).

Moreover, the assimilation of boron decreases when the pH increases. A pH below 9, the chemical element is removed from the soil by the plant in the form of boric acid H_3BO_3. Similarly, there is a negative correlation between soil pH and uptake of boron, especially for pH> 6.5 (ELalaoui, 2007).

CONCLUSION

Based on estimated foliar concentrations we can note that in the orchards studied little of nitrogen, calcium, manganese, potassium, magnesium and zinc are good development standards for the variety of cultivated avocado trees. wheras, in all orchards excessive concentrations of phosphorus and boron, and the deficient concentrations of copper could be dangerous to this variety.

Thus, it is therefore of great interest for farmers to consider these results to expect a better production from their farms and avoid the causes of nutritional imbalance through performing soil depth leaves analysis of their orchards (trace elements and pH) and controlling the quality and quantity of fertilizers they use. So that to save the environment.

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Table 1: Concentrations of some mineral elements in mg / 100g of the pulp fruit of 'Fuerte' variety

Element	date		Element	date	
	October	February		October	February
Potassium	640,00	410.00	Manganese	0,19	0,17
Magnesium	18,00	30.00	Aluminium	0.40	0,080
Phosphorus	25,00	32.00	Copper	0,20	0,40
Silicon	4,00	2,00	Chrome	0,06	0,16
Calcium	7,00	11.00	Titanium	0,05	0
Sodium	6.00	12.00	Lithium	0,001	0,02
Iron	1,80	0,45	Nickel	0,40	0,03
Boron	0.50	2,80	Silver	0,003	0,008
Strontium	0,37	0,50	-	-	-

Table2: Concentrations of some vitamins in fruit of 'fuerte' cultivar according to the date of harvest

Element	date		Element	date	
	October	February		October	February
β- Carotene, IU	410	370	Niacin, mg	1,5	1,74
α- Tocopherol, IU	2,5	4,2	Panthothenic acid, mg	0,78	0,95
Ascorbic acid, mg	4,0	7,2	Pyridoxine, mg	0,26	0,20
Biotin, mg	2,5	2,3	Riboflavin, mg	94	100
Choline, mg	21,0	15,0	Thiamin, mg	100	78
Folacin, mg	105	42	-	-	-

Table 3: Avocado culture Location, all varieties (crop of agricultural company 2013/2014); ND: not determined number

Regions	**Producers number**	**Superficie (ha)**		
		Young plantations	**Productive plantations**	**Total**
Gharb	98	104.00	1009	1113.00
Rabat/ Sale	ND	167.50	795.50	963.00
Loukkos	120.00	203	500	703.00
Doukkala abda	20	35	60.00	95.00
Meknès tafilalet	3	6	9.0	15.00
Chaouia- Ourdigha	3	0	4.5	4.5
TOTAL	244	515	2378	2893

Table 4: The foliar concentrations of chemical elements in the studied orchads and the norms of the favourable values to the Development of the cultivar 'Fuerte'.

Element	**required concentrations**	**Noted concentrations in the orchards studied**												
		V_1	**V_2**	**V_3**	**V_4**	**V_5**	**V_6**	**V_7**	**V_8**	**V_9**	**V_{10}**	**V_{11}**	**V_{12}**	**V_{13}**
N	1,6 – 2 %	1,92	**1,55**	1,65	**2,18**	1,89	**2,50**	**1,53**	1,68	1,93	**1,48**	1,76	1,74	1,90
P	0,09 – 0,12 %	**0,21**	**0,16**	**0,18**	**0,21**	**0,20**	**0,24**	**0,18**	**0,18**	**0,21**	**0,15**	**0,18**	**0,19**	**0,19**
K	0,5 – 1,0 %	0,89	0,56	0,66	0,74	0,91	0,77	0,89	0,77	0,83	0,62	0,70	0,97	0,68
Ca	1,0 – 3,0 %	1,76	2,53	2,31	1,93	2,02	2,42	1,65	1,94	1,81	1,91	1,55	1,51	1,77
Mg	0,3 – 0,8 %	0,52	0,62	0,61	0,65	0,59	0,36	0,37	0,48	**1,46**	0,71	0,41	0,46	0,37
B	30 – 80 ppm	**26**	**22**	**19**	**24**	**25**	**19**	**19**	**26**	**20**	**27**	**26**	**29**	**20**
Cu	5 – 15 ppm	**4**	5	5	7	5	**3**	5	**4**	**4**	**4**	7	7	6
Zn	20 – 150 ppm	**19**	24	20	22	25	24	22	25	107	21	50	25	20
Mn	30 – 500 ppm	-	160	138	87	165	61	158	124	28	57	77	221	78