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Evaluation of seasonal nutrient status in the leaves of different olive varieties grown on calcareous soils

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Abstract

The study was conducted for two successive years at a private farm in El-Saf, Giza, Egypt on 19 years old trees of olive cultivars, Picual, Aggizi and Manzanillo, grown in calcareous soils. Leaf nutrients were measured bi-monthly during the 2001-2002 growing season. The study revealed that most of nutrients in the soil were at inadequate level. Nutrient concentrations in the leaves of the three cultivars were nearly the same. Results revealed that leaf N ranged between low to satisfactory. P contents were adequate in spring while inadequate in summer. K leaf contents were adequate. Peaks of Mg were found to be the highest during winter. Ca peaks were observed during March-June. Fe and Zn were inadequate while Mn was adequate. The concentrations of Fe, Mn and Zn peaked during June, which could be due the repeated foliar application of these nutrients during this period. The seasonal nutrient changes (N, P, K, Ca, Mg, Fe, Mn, Zn and Cu) of the olive leaves are supposed to be used as a guide for proper fertilization. Nutrients should be added as acidic fertilizer to the soil, which is useful in calcareous and high pH conditions.

Key words: Olive, *Olea europaea* L., leaf nutrients, seasonal variations.

Introduction

During recent years Egypt, calcareous soil under cultivation in was estimated to reach about one million feddans (1 feddan= 0.42 ha). The programs of agricultural development in Egypt aim to increase the cultivated areas with olive trees in these soils. Soils in El-Saf area are highly calcareous. These soils contain about 3% to more than 20% $CaCO_3$ with pH values in the range of 8.0 to 9.0. Their inherited fertility is low. Olive is extensively grown in these calcareous soils. Proper nutrient management is required to grow olive successfully on such soils. Olive trees do much better with changes to their nutritional status through good nutrition. Controlled nutrient supply during different seasons can produce higher yield.

Few data are available concerning seasonal nutrient status. Soil and leaf analysis have been developed over the years to help growers to diagnose tree nutrient status and soil nutrient availability and make adjustments on fertilization programs accordingly. The purpose of the present investigation was to detect seasonal changes in the nutrient status of some olive varieties grown in calcareous soils, to be used as a tool to optimize fertilizers use.

Materials and methods

The study was conducted at an olive orchard established on calcareous soil located in El-Saf, (Giza, Egypt) during two successive years (2001-2002). The orchard contained nineteen years old olive trees (*Olea europaea* L.) of three different varieties namely, Picual, Manzanillo (dual purpose) and Aggizi (table olives), the three most common olive varieties grown in this area. Trees were uniform in growth and cultivated at 6 x 6 m distance (278 tree/ha). The trees were in good physical condition, free from insect damage and diseases and were subjected to the same management treatments. The trees received the following agricultural practices during the period of the study:

Fertilization: (1) 28 m^3 cattle manure ha^{-1}, in January; (2) 278 kg N ha^{-1}, as ammonium nitrate (33.5% N), added in 4 equal doses in March, May, July, and August. (3) 74 kg P_2O_5 ha^{-1}, as single super phosphate (15.5% P_2O_5) in 1 dose in February; (4) 228 kg K_2O ha^{-1}. as potassium sulfate (48% K_2O) in 3 equal splits in March, May and July; (5) concerning micro nutrient fertilizers, the trees were sprayed three times in March, May and June using a compound containing 6.5% Zn-EDTA, 4.5% Mn-EDTA and 2.25% Fe-EDTA in concentrations of 1.5 g L^{-1} in the spray solution.

The trees were drip irrigated from deep well of water containing 838 ppm total soluble solids with pH 8.24 for 8 hours every 2 days from the beginning of June till the end of September. Then the irrigation period extended to 4 days during the rest eight months. Total amount of water used was 5450 m^3/year/ha. Plant protection treatments were applied when required. The average yield/tree was 8.33 kg in non-bearing year (2001), and 35.57 kg, in bearing year (2002).

Sampling

Soil samples: Samples were taken from the root tip zone of the trees in May. Soil samples were air dried then sieved to pass a 2 mm sieve.

Leaf samples: Leaves from the selected trees were collected from the fully mature leaves of spring flush in the first week of every month. The 2nd and the 3rd leaves from the fruit bearing branches of about 20 trees, 5-10 leaves from each, were randomly taken around the tree. During the two years, the number of samples were 36 for each variety. The samples were washed with tap water, 0.01 N HCL and distilled water, respectively, then dried at 70 ^oC and ground in a stainless steel mill.

Analysis: Soil samples were analyzed for texture with a hydrometer (Kilmer and Alexander, 1949), for pH and electric conductivity (EC) using water extract (1:2.5) method, (Jackson, 1973), for total calcium carbonate ($CaCO_3$%) by calcimeter method as described by Alison and Moodle (1965) and organic matter (OM%) content according to Walkley and Black (1934) using potassium dichromate (Chapman and Pratt, 1978). Nitrogen calculated from soil organic matter due to its quick changes, depending on environmental factors. Phosphorus was extracted using sodium bicarbonate (Olsen *et al.*, 1954). Potassium (K^+) and Magnesium (Mg^{+2}) were extracted using ammonium acetate. Iron (Fe^{+2}), Manganese (Mn^{+2}), Zinc (Zn^{+2}) and Copper (Cu^{+2}) were extracted using DPTA (Lindsay and Norvell, 1978).

The plant material was digested using an acid mixture consisting of nitric, perchloric and sulfuric acids in the ratio of 8:1:1 (v/v), respectively (Chapman and Pratt, 1978). Nitrogen (N) was determined in the dry plant material using the boric acid modification described by Ma and Zuazaga (1942), and distillation was done using a Buechi 320-N_2-distillation unit. Phosphorus was photometrically determined using the molybdate vanadate method according to Jackson (1973). Potassium was determined using flame photometer Eppendorf. Mg^{2+}, Fe^{+2}, Mn^{+2}, Zn^{+2} and Cu^{+2} were determined using the atomic absorption spectrophotometer PMQ3. The soil data were evaluated using the criteria published by Ankerman and Large (1974) and Lindsay and Norvell (1978), whereas the leaf analysis data were evaluated according to the criteria suggested by Bouat (1964), Hartmann *et al.* (1966) and Recalde and Chaves (1975).

Results and discussion

Soil properties and nutrient status of soils: From Table 1, it can be noticed that soil pH had high value (8.33). Under such high alkaline conditions, availability of some nutrients is expected to be low. Electric conductivity (EC) was high. The soil samples were found to be high in $CaCO_3$; contained greater than 10% $CaCO_3$ which is expected to have an adverese effect on the nutrient availability (Ankerman and Large, 1974). The soil of the orchard was very poor in organic matter content (0.31%).

Table1. Soil characteristics

Characteristic		Nutrient content	
Sand %	93	N (mg/100g)	15.50 VL
Silt %	04	P (mg/100g)	4.55 H
Clay %	03	K (mg/100g)	8.26 VL
Texture	Sandy	Mg (mg/100g)	20.00 L
pH	8.33H	Ca (mg/100g)	270.00 H
E.C dS/m	0.68H	Na (mg/100g)	37.20 H
$CaCO_3$ %	10.8H	Fe (mg/kg)	15.57 M
OM%	0.31VL	Mn (mg/kg)	3.33 VL
		Zn (mg/kg)	0.80 L
		Cu (mg/kg)	0.83 L

VL= very low L= low M= medium H= high

Table 1 also depicts the average values of the major nutrient concentration in the soil samples, total nitrogen was very low and available P-content was 4.55mg/100 g soil. According to (Ankerman and Large, 1974), this P-concentration is considered to be high. However, under the conditions of such soil (high $CaCO_3$ and high pH), the availability of P is expected to be reduced, and plants might suffer from P- deficiency. Extracted potassium levels seem to be very low. Therefore, potassium fertilizers were added to compensate the K deficiency in the soil, especially those soils of high sand content as the soil under investigation. The extractable Ca was high, while the extractable Mg was low. In this context, Mengel and Kirkby (1987) mentioned that Mg^{+2} uptake by plants can be restricted by the high levels of Ca^{+2} in the root medium, which might lead to Mg deficiency in plants, in spite of its high levels in the soil.

Calcareous soils may contain medium levels of total Fe, but in unavailable forms to plants. The extractable Fe^{2+} level of the present soil samples was in the medium range and Mn^{+2} was very low, and it tends to form Mn – organic matter complexes under such high pH conditions, which makes it less available to trees. Available Zn^{+2} can be reduced due to formation of Zn-carbonates. The values of Zn in this study were low. Also, Cu was low in the soil, as it's known in most calcareous soils, which contain inadequate levels of available copper. In addition, the uptake of micronutrients is depressed by increasing P contents in the soil.

Nutrient status of olive leaves: It is well known that olive trees are very efficient in absorption of nutrients from the soil. Nutrient concentration in the leaves followed the same behaviour in the cultivars under study. Nitrogen concentration in the leaves ranged between 1.0-2.6% (on dry matter basis) (Fig. 1), which tends to be low. This may be due to high leaching of ammonium nitrate in such soil with 93% sand. It is recommended to add nitrogen as ammonium sulphate, which is less leached and more efficient in calcareous and high pH conditions. Johnston (2004) reported that when ammonium sulphate is applied one pH unit can be decreased and this pH change is important for P supply and also for micronutrient supply. P-concentrations in the mature spring leaves ranged between 0.10-0.20% (Fig. 1) which are adequate, while in summer, they were less than 0.10%.

Potassium concentrations in the leaves ranged between 1.0-2.2% (Fig.1), which, is in the adequate range. Some researchers mentioned that low concentrations of K in olive leaves are not uncommon in olive groves planted on calcareous soils. Higher magnesium concentration peaks were found during winter (November-January), while calcium concentrations were high during March-June.

Fig. 2 illustrates the micronutrient concentrations in the leaves of olive trees throughout the year. Fe concentrations can be higher than, equal to, or lower than those in normal trees. Thus, this disorder on calcareous is not always attributable to Fe deficiency; a high concentration of calcium in the soil is likely to make iron deficiency more severe, a condition known as lime-induced Fe chlorosis. The severity of the disorder increases at high pH. In general, Fe-concentrations were inadequate and peaked in May-June to reach about 200-300 ppm. Mn^{2+} concentrations followed the same trend in the three cultivars under study. Concentrations of Mn were adequate and peaked in June to reach the range between 70-80 ppm. Olive trees are known to be very sensitive to Zn deficiency. Marschner (1993) found that in soils with very high pH and $CaCO_3$ and very low in organic matter, availability of Zn to plant roots is extremely low. As a result of factors described above most Zn concentrations in this study were low. Zn concentration was less than 25 ppm except in June when it reached to about 60 ppm. The concentrations of Fe, Mn, and Zn (peaked during June), were affected by the repeated foliar application of these nutrients

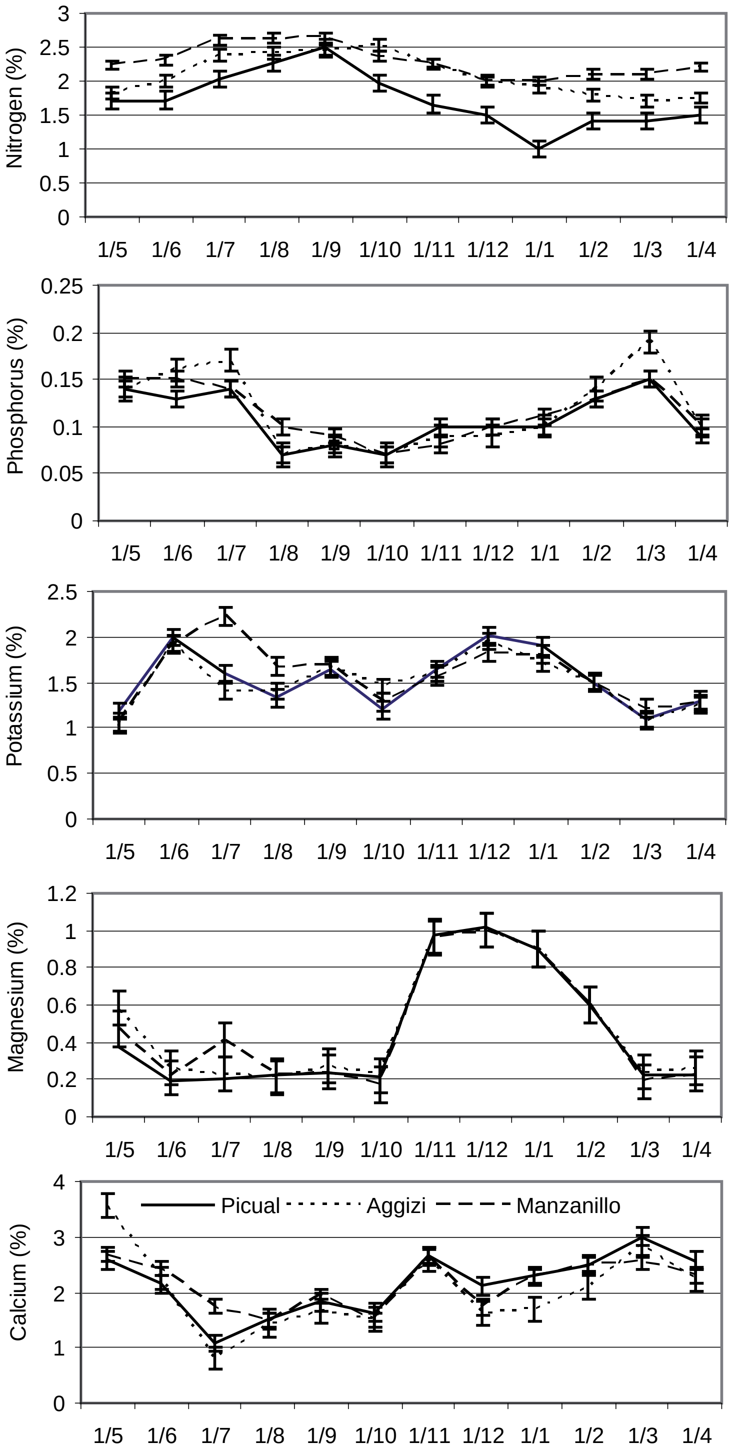

Fig. 1. Monthly concentrations of macronutrients in the leaves of different olive cultivars (Each value is the mean ± SE of three replicates)

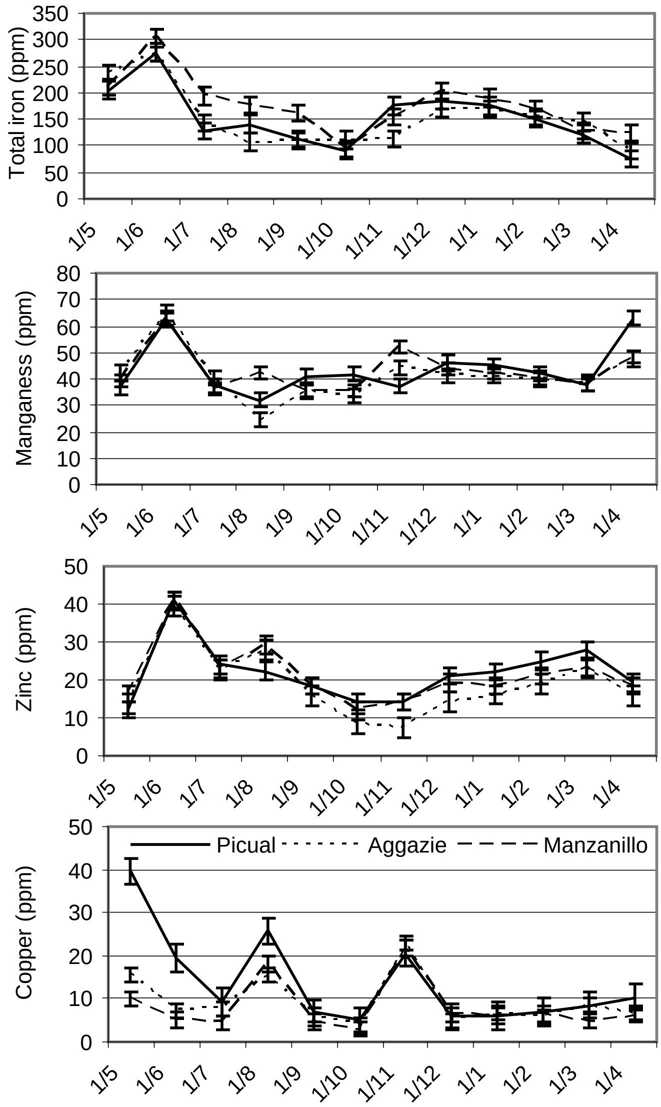

Fig. 2. Monthly concentrations of micronutrients in the leaves of different olive cultivars (Each value is the mean ±SE of three replicates)

to trees after fruit setting during this period.

The peak of Fe, Mn and Zn in June, could be due to foliar application of these nutrients, which improved its concentrations in leaves. Boaretto *et al.* (2002) and Sanchez and Righetti (2002) found that when severe Zn deficiency symptoms appear, early spring foliar sprays could increase the micronutrient concentration in the targeted organs. Also, Swietlik (2002) mentioned that it could stimulate vegetative growth. Similar results were found by Shaaban and El-Fouly (2005).

It is well known in calcareous soil that Cu-availability and consequently its concentration in leaves of grown plant are expected to be low due to high soil pH. In this study Cu-concentration was found to be less than the adequate range in most samples. In some samples Cu-concentration was found to be high. This might be due to use of Cu-containing pesticides.

It could be concluded that nutrient concentration in olive leaves is greatly affected by soil characteristics as well as farm management. Soil characterstics and plant nutrient requirement should be considered when preparing a fertilizer recommendations.

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