LEAF ANALYSIS AS A GUIDE TO FERTILIZATION OF CITRUS TREE [1]

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INTRODUCTION

The use of leaf analysis as a basis for fertilizer recommendation is now widely practised in the U.S.A., and there appears to be increasing interest in other citrus growing areas of the world.

Leaf analysis is used to determine the nutrient status of the tree. It is a valuable aid in obtaining a better understanding of the fertilizer requirements of citrus trees; however, the data obtained as a result of leaf analysis must be used in conjunction with other facts known about the tree.

The use of leaf analysis for evaluating the nutritional status of fruit trees assumes that yield, fruit quality, and plant growth are closely related to the concentration of essential minerals in the leaves at the time of sampling[2],[3]. The quantity of an element in the leaves of a plant is a function of several interrelated factors[14],[15]. Among these are leaf age, nutrient supply, moisture conditions, climatic conditions, soil type, crop load, and kind of plant[17]. Leaf analysis integrates the factors that influence the content of nutrients in leaves up to sampling[4],[14],[15],[17]. The physiological basis for leaf analysis rests on the following assumption : ⓐ nutrients absorbed from the soil are translocated throughout the plant but are concentrated primarily in the leaves; ⓑ the leaf is a primary site of plant metabolism; ⓒ leaf composition indicates change in nutrient supply, and ⓓ maximum yield and satisfactory fruit quality are quantitatively related to range of leaf analysis values[2],[3], [14], [15], [17]. when the concentration of an essential element in leaves falls outside the optimum range for a crop like citrus, the addition or omission of that element in the fertilizer should produce a definite response[4]. Reliable tables of leaf standards must be available for a particular tree crop before leaf analysis results can be properly evaluated[4],[14],[15]. The quickest method of establishing approximate leaf standards is to conduct a survey of commercial planting with good production records[3]. Leaf analysis values from these high yielding tree are used in setting up tentative optimum range for the essential mineral elements.

Reliable leaf analyses standards become available only after the results of surveys and sand culture experiment are tested against the values obtained from long term fertilizer experiment in the field[15].

Growers depend very heavily on leaf analysis to add minerals. The use of leaf analysis to indicate nutrient availability has long been accepted and its advantages and disadvantages have been recounted[14]. However, its use as a practical tool has awaited the develop-

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ment of standards calibrated with differential treatments on producing tree under field condition ; and the growth of commercial laboratories capable of making critical and rapid analyses. In this paper some of the principles of leaf analysis and some of the factors that are particularly important for citrus are briefly discussed.

LEAF ANALYSIS STANDARDS

A certain level of nitrogen in the leaf has little meaning by itself. It must be related to standards. Fortunately 2 such sets of standards have been worked out for citrus. These are : 1, Some workers Chapman[4] and Deviller and Beyers[6] favor the use of a table of leaf standards compiled from the analysis of 4–to 10–month old leaves taken from fruit–bearing terminal shoots. These workers select leaves from fruit–bearing terminal shoot on the assumption that these leaves are easier to identify and sample. On the other hand, most of the other workers, e.g., 2. Smith[15], Jones and Embleton[8], and Koo[10], use standards based on leaves taken from non–fruiting terminal shoots. Smith[15] working with Florida sweet orange, uses a table of leaf standards based on 4– to 7–month old spring flush leaves taken from the middle of non–fruit–bearing shoot. Some workers Embleton and Jones[8] take leaves that are 5– to 7– months old based on the observation that there is a seasonal change in nutrient elements but the rate of change is not constant and the least change occurs in leaves at this time. Thus, this period is selected for sampling[8]. There appears to be a trend towards the Smith[15], Embleton and Jones[8], Koo[10] standards based on non–fruit–terminal shoot. The reasons for this are : Firstly, the leaves from fruit–bearing terminal shoot show a much greater variation in macro–nutrient composition than leaves from non–fruit–bearing terminal shoot. Secondly, the crop load on a fruiting shoot affects the nutrient status of the leaves, especially in case of potassium and magnesium. Leaves on fruiting shoot have lower nutrient levels than those on non–fruiting shoot. Thirdly, leaves on non–fruiting shoots have a more direct influence on next seasons crop as most of the fruit will be borne on these shoot. In three cases the standards have been correlated with yield, fruit size and quality under a wide range of field conditions throughout the world[18].

RANGE OF MACRO AND MICRO ELEMENT IN CITRUS LEAF

A range of macro and micro nutrient leaf analysis values for citrus trees are shown in Table 1. An element is deficient when its leaf analysis value indicates a possible reduction in yield and fruit quality. Foliar symptoms will appear for most of the element when their leaf analysis values fall below specified minimum values[4],[15].

Nitrogen : Leaf values in the very low range are related to reduced yield and slightly reduced fruit quality for some elements. However ; low, but not deficient, values for element, such as nitrogen, are often associated with increased external fruit quality of orange [4],[9],[15], but high values of N increased green color of fruit. The nonuniformity of color of the high nitrogen fruit is due to more regreening on a portion of the surface of the fruit ; texture is coarsened ; peel thickness is increased ; percent juice is decreased ; and susceptibility to rind breakdown is increased[9].

Table 1. Satisfactory Range of Nutrient Element in Standard Samples of Leaves from Commercial Citrus Groves in Florida.

	Element	Chemical Symbol	Satisfactory Rang
macro	Nitrogen	N	2.3 —2.9
%	Phosphorus	P	0.09—0.15
	Potassium	K	1.2 —1.7
	Calcium	Ca	2.5 —5.0
	Manganese	Mg	0.30—0.45
micro	Copper	Cu	5 — 10
ppm	Iron	Fe	40 — 60
	Magnesium	Mn	20 — 75
	Zinc	Zn	25 — 80
	Boron	B	40 — 150

Phosphorus : The range indicated apply only when the nitrogen level in leaves falls to the optimum or lower range. If nitrogen is high or in excess, then the standards of classification tend to be displaced or invalidated, thus, phosphorus values inthe low range do not always indicate an inadequate supply of this element, and values in the optimum range associated with high nitrogen might actually increase to the excess range if the nitrogen supply were reduced without reducing phosphorus supply as reported by Smith[16].

When phosphorus is in the low range, yield may be reduced, and the fruit is well colored but otherwise of poor quality. when phosphorus is high,fruit color may be poor and juice quality somewhat low, but yeild unaffected[16].

Potassium : Potassium values in the leaves, about 0.7% will maintain yield but quality will be affected as discussed by Embleton, Jones and Platt[7]. Potassium addition generally reduce the concentration of leaf magnesium regardless of the initial level. If it is relatively low, potassium application can induce or aggravate magnesium deficiency, as shown by Burns[3].

Potassium nitrate increased the nitrogen concentration in the leaves by 0.1%. That an increase in leaf potassium reduces the concentration of leaf calcium is a common occurrence[7].

A negative statistical correlation exists between high leaf potassium and soluble solid of orange as reported by Willson[17]. Excess leaf analysis values may be related to decreased yield, inferior fruit quality, and reduced vegetative growth, Chapman[4] and Smith[16].

Calcium : High calcium in leaves usually indicates a calcareous soil in which availabilities of other major bases and some heavy metals are likely to be a problem with citrus[16]. On neutral or acid soils, high leaf calcium usually reflects low availability of potassium either through high fixation by the soil or through inadequate ferilization on high acid,

low-exchange capacity soil. Leaf calcium is very responsive to the level of potassium fertilization. Thus, just as there is a relatively wide optimal range exists for calcium, a low concentration of calcium in leaves may be indicative of excess soil acidity. poor soil aeration, or unbalanced nutrition from excess element such as potassium, sodium, aluminum, copper, zinc, or manganese also affects availability of calcium. [13]

Magnesium : when manganese is low to deficient, chlorosis and defoliation are mild to severe, but quality is not adversely affected until the deficiency is severe[16].

Boron : If leaves are low on boron, it is likely to be associated with somewhat high phosphorus and manganese and low potassium values. A level of available boron in the soil sufficient to produce toxic concentration in leaves is likely to lower calcium and increase potassium concentration in leaves somewhat[16].

Iron, Copper, Zinc, Manganese: The heavy metals all tend to derange normal mineral metabolism when deficient. Deficiencies of these elements typically are associated with high nitrogen and potassium and low calcium in leaves. In fact, zinc deficiency was once thought to be a calcium deficiency because affected leaves were noted to be always abnormally low in calcium[16].

SAMPLING METHODS

Sampling is extremely important. A sample must be properly collected for an analysis is no better than the sample[8],[12].

In general, workers in Florida[16] select the use of 20 uniform tree in each grove for leaf sampling, but some workers in California[12] use 35-50 trees to make an adequate sample. In one young grove ; however,only 10 trees were according to a method used by Reitz and Long[13]. Depending on the size and shape of groves, one of 2 sampling patterns was employed. A diamond-shaped sampling pattern was used for sampling most of the larger, square-shaped groves. A zig-zag sampling pattern was suggested for the long narrow groves by Cooper[5]. Leaves are taken from the 4 sides of tree. These are taken from a north and east position from every other tree and south and west position from the alternate tree. The leaves are taken from the tree in the sampling pattern at a height of 1 to 7 feet above the ground[4],[12]. One leaf from each of about 10 exposed terminal around the periphery, combined with those from other tree, makes a sample [15]. Other workers[15] use a leaf sample consisting of 100 spring flush leaves, (5 leaves per tree) taken from the middle of non-fruit-bearing shoot on 20 trees in about the same tree-positional, sampling pattern.

SAMPLE PREPARATION

Leaves may be collected in the field in ordinary kraft Paper or plastic bags and either stored in an ice box or cold room at about 0 to 5°C until used or washed and placed immediately in the oven[16].

If they are to be washed, it is desirable to prevent them from wilting or drying out. A convenient routine washing procedure is to place the leaf sample in a 2 to 3 liter wide-mouth glass jar with a screw top, add about 500 mls. of 0.3 N HCl and about 1 gram of a

detergent such as a sodium laural sulfate, shake vigorously for 2 minutes, decant, then rinse and shake with 4 to 5 successive portions of distilled water in rapid succession until all the detergent is removed. Leaves should not be submerged long enough to cause translucent areas in them, indicating intrusion of the washing solution into the intercellular spaces of the mesophyll. In case of heavy residues difficult to remove, it may be necessary to scrub each leaf individually with acidified detergent solution. Leaves placed loosely in open paper bags should be dried to a constant weight in a force-draft oven at 50° to 65°C, then ground to a fine powder in a suitable mill (such as an intermediate-sized wiley) , thoroughly mixed, then stored in vermin-proof containers. Immediately before weighing out a portion for analysis, the powdered tissues should be redried for about 12 hours in an oven at a standard temperature 65°C[16].

ANALYTICAL METHODS

Nitrogen was determined by using a semi-micro Kjeldahl procedure described by Anderson *et al.* [1]. the vanadate method was used for determining leaf phosphorus[1], calcium, manganese, potassium and other elements were determined with atomic absorption and flame emission procedures[11]. The spectrographic technique for determination of certain micro-elements was used in several studies by Smith[15].

In a regular citrus leaf analysis program, leaf samples are obtained and nitrogen determined each year. However potassium, phosphorus, manganese, and calcium may be determined about every fifth year, if no problem is indicated in first analysis. Other elements, such as zinc, etc., are analyzed when one is needed to confirm conficiency symptoms, changes or adjustment in fertilizer application are then made on the basis of the analytical data with full knowledge of the past fertilizer history. This then,is the current status of leaf analysis as a guide to fertilization[8].

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柑桔葉片分析在施肥上之應用

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中 文 摘 要

葉片分析作爲柑桔施肥基準的方法，在美國已廣泛應用，因可直接診斷植株之營養狀況，更能瞭解其需肥程度，故在施肥上更爲精確，且經濟有效。本文就是柑桔葉片分析中有關採樣技術、樣品之製備、分析方法與各要素之含量標準等問題加以闡述，期能推薦於本省果農應用。

葉片分析受外界因子影響甚鉅，如葉齡、施肥、果實產量、品種、濕度、氣候與土壤狀況等。通常氮素每年分析一次，其他磷、鉀、鈣、鎂約五年分析一次，微量元素則依其葉部徵狀發生後加以分析。