

Nutrient Diagnostics in Citrus: Are they Applicable to Current Season Crop

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Citrus is one of the premier fruit crops, potentially a promising source for providing nutritional security, since staggering 900 million people are globally proclaimed to be under-nourished [1]. In most of the perennial crops like citrus, identifying nutrient constraints in standing crop and addressing them within the same growth period warrants a truly complex exercise to implement effectively. Effect of nutrients on plant growth and development has been studied for over 350 years since the experiments of van Helmont in 1648 [2]. Exciting progress has been made in the past 50 years to develop and improve diagnostic techniques of identifying nutritional constraints in order to define the fertilizer requirement. Diagnostic tools of nutrient management such as leaf analysis [3], soil analysis [4,5], juice analysis [6], to some extent biochemical analysis [7] and at times sap analysis [8], all have been under continuous critical scrutiny and recurrent use. It is abundantly clear that no one of these alone is capable of addressing the nutritional problem of current standing crop with the exception of combined use of leaf and soil analysis having comparatively some added advantages [5,9] with respect to their application in field. Success of current citrus nutritional research, therefore, depends upon how precisely two major problems are addressed. Problem one, that manifests in the correct and timely identification of nutrient deficiency as a resultant effect of disturbed metabolic processes, especially where the occurrence of multi-nutrient deficiency is a common feature and secondly, the method to execute remedial measure, to address the deficiency of a particular nutrient. These two efforts collectively minimize the chances of current season crop getting suffered on account of sub-optimum nutrition. There are definite limitations with the leaf analysis technique currently in use where concentration of nutrients in leaf needs to stabilize first, to collect mature leaves at a stage transition from sink to source [10] before subjecting samples to chemical analysis. This whole exercise leaves very little time for a plant diagnostician to execute the recommendations of leaf analysis in the standing crop or to address the nutrient constraints within the same growth period. Most traditional method of nutrient constraints diagnosis is the one based upon deficiency symptomologies. This method is more of an aid to undertake post-mortem of reasons behind the genesis of nutrient deficiency rather than using as an effective diagnostic tool. On the other hand, determination of critical levels and the mineral composition of plants (nutrient balance), gives only a static view of the problem, because the biologically active form of nutrient is not determined [11]. Additionally, many a times, the discrepancies between diagnosis of nutrient status of leaf and soil are resolved through long term field response studies. The growers till then continue to obtain sub-optimum production on account of occurrence of one or other nutrient deficiencies. These arguments raise the big question mark about the efficacy of current nutrient diagnostics in addressing the nutrient constraints in standing crop. It means such diagnostics reveal more about the future fertilization to be followed. Productivity of the plant depends essentially on the nutrient balance and the biological activity. Establishment of absolute figures of normal, deficient or excess nutrient levels are not real, unless the dynamic aspect of leaf nutrient concentration is considered. Studies by Coruzzi and Bush [12] have shown that nutritional status of the responsive tissues transmit signals as a regulator of gene expression and at times, that can become a limiting factor in the process of plant development. There are interesting

improvements such as the determination of the nutrient evolution along the vegetative cycle, the substitution of the critical levels by the critical zone, fractionating the nutrient contents (especially the biologically active ones), and finally implementing the biochemical diagnosis. For the latter, the use of activities of specific enzymatic systems and also of metabolites concerned with photosynthesis has a good potential to improve the accuracy of nutrient constraint diagnosis over other conventional methods of nutrient diagnosis. The levels of enzymatic activity could be effectively used as an alternative diagnostic tool to leaf analysis (distinction between Fe- and Mn- deficiency or N- and S-deficiency could be possible through application of metalloenzymes only quite early in the season [13] that could further be equipped with better technical soundness with regard to field application. In this regard, Ichiki [14] earlier developed colour standards for identifying nutritional problems in field. Practical colour charts of nine shades designed for field nutritional diagnosis, is composed of 172 types from GY2 to GY8 using the Munsell colour system based on leaf colour measurement. While Sanz and Montanes [15] proposed flower analysis as an equally effective option to leaf analysis for nutritional constraint analysis based on relationship observed between nutrient concentration of flowers at full bloom and leaves taken at 60-120 days after full bloom. These headways could be very handy for the standing crop, irrespective of whether or not diagnosis performed at what critical growth stage. Application of non-destructive sensor-based hyper spectral proximal sensing in years to come could further offer a strong practical possibility to do post-diagnosis rectification in current season crop at any growth stage of crop.

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