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DRIS norms for identifying yield-limiting nutrients in sapota (*Manilkara achras* (Mill). Fosberg) cv. Cricketball

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ABSTRACT

Diagnosis and Recommendation Integrated System (DRIS) identified forty-five nutrient expressions as diagnostic norms from data colleted by surveying seventy-four sapota gardens in Karnataka and dividing the whole population into two sub-groups, namely, low and high yielding, during the year 2005-06. These expressions have shown higher variance and lower coefficient of variation found to have greater diagnostic precision, viz., N/K (0.989), Mg/N (0.264), N/Zn (0.117), Mg/K (0.258), Zn/K (8.609), S/Mg (0.666), Mg/Zn (0.031) etc. The Nutritional Balance Index indicated an overall imbalance of nutrients based on the sum of indices, irrespective of the sign. The diagnosis of nutrient imbalance through DRIS indices indicated that potassium, followed by nitrogen, was the most yield-limiting nutrient among major nutrients and as were copper and zinc among micronutrients. In addition, five nutrient ranges were derived using mean and standard deviation as low, deficient, optimum, high and excess for each nutrient to serve as a guide for diagnostic purposes. Optimum N in the leaf ranged from 1.60 to 1.85%, P from 0.10 to 0.13%, K from 1.63 to 1.85%, Ca from 0.54 to 0.74%, Mg from 0.42 to 0.47% and S from 0.28 to 0.37%. Among micronutrients, optimum iron concentration in the leaf ranged from 113 to 161 ppm, Mn from 21-31 ppm, Zn from 14 to 17 ppm and Cu from 5 to 7 ppm for 'Criketball' variety of sapota.

Key words: Sapota, index tissue, nutrient norms, DRIS, Nutritional Balance Index

INTRODUCTION

To feed balanced nutrition to its 1000 million populations, India needs 92 million tonnes of fruits. Sapota constitutes 1.8% of the share of the country's total fruit production, with an annual production of 8.3 lakh metric tonnes (Anon., 2004). As sapota is an evergreen tree producing several vegetative and floral flushes during the year, and consequently fruits, requires a substantial amount of nutrients for maximizing yield and quality. Hence, its nutrient requirements need to be carefully monitored through modern nutrient management strategy, i.e., leaf analysis, for high productivity. It was planned to develop leaf nutrient standards for sapota using the diagnosis and recommendation integrated system (DRIS), which provides a means for simultaneous identification of imbalances, deficiencies and excesses in crop nutrients and ranking them in order of importance (Beaufils, 1973) as no established standards are yet available for this purpose. This methodology was used successfully to interpret results of foliar analysis in crops such as grape (Bhargava and Raghupathi, 1995) and rose (Anjaneyulu, 2006).

MATERIAL AND METHODS

Sample collection

For establishment of standard values or norms through DRIS, 370 leaf samples were collected from seventy-four sapota gardens in Karnataka during 2005-06. At each site, a composite sample of recently matured tenth leaf from the apex was collected as index tissue. Leaf samples were decontaminated following standard methods (Bhargava and Chadha, 1993). Excess water was removed by pressing the leaves between folds of a blotting paper. The petioles were dried in an oven at 75°C for 72 h and powdered in a Cyclotec Mill before storing. The samples were analyzed for different nutrients (except nitrogen) by digesting 1g of the material in di-acid mixture (9:4 ratio of nitric and perchloric acids) using standard analytical methods (Jackson, 1973). Nitrogen was estimated by the micro-kjeldhal method, whereas phosphorus, potassium and sulphur by vanado-molybdate, flame-photometer and turbidometric methods, respectively. Calcium, magnesium and the micronutrients Fe, Mn, Cu and Zn were analyzed using Atomic Absorption Spectrophotometer (Perkin-Elmer-A-Analyst-200). Thus, a data bank was established for the entire population.

DRIS norms computation

Using DRIS, the whole population was subdivided as high- and low-yielding (Beaufils, 1973) by earmarking 14 tonnes/ha as the cut-off yield among gardens, although Letzsch and Sumner (1984) indicated that the actual cut-off value had little effect on developing norms as long as it was not too low. Each parameter was expressed in as many forms as possible, e.g., N/P, P/N, N´P, etc. and mean values for each nutrient-expression, together with their associated CVs and variances, were then calculated for the two populations. The mean values (in the high-yielding populations) of nutrient-expression were chosen as diagnostic norms. In making the selection, three basic principles were borne in mind: (i) to ensure that norms were based on Gaussian distribution of yield versus nutrient-expression values, otherwise calculated means (norms) for nutrient expressions that might differ from the true values at maximum crop yield. (ii) to select nutrient expressions for which variance ratios were relatively large, thereby, maximizing the potential of such expressions to differentiate between healthy and unhealthy plants. (iii) to select equal number of nutrient expressions for all the nutrients since this was an absolute requirement of the mathematical model (Walworth and Sumner, 1987).

DRIS indices

DRIS provides a means of ordering nutrient ratios into meaningful expressions in the form of indices. DRIS indices were calculated as described by Walworth and Sumner (1987) using the following formula, with example of one nutrient as shown below:

$$N = 1/10[-f(P/N)-f(K/N)+f(N/Ca)+f(N/Mg)-f(S/N)-f(Fe/N)+f(N/Mn)+f(N/Zn)-f(Cu/N)+f(N/dw)]$$

Where, $f(N/P) = \frac{N/P}{n/p} - 1 \ | \ \frac{1000}{CV}$ when $N/P > n/p$

and $f(N/P) = 1 - \frac{n/p}{N/P} \ | \ \frac{1000}{CV}$ when $N/P < n/p$

where N/P : the actual value of the ratio of N and P in the plant under diagnosis

n/p : value of the norm (which is mean value of the high-yielding unit)

CV : coefficient of variation of high yielding population

Similarly, indices for other nutrients have been calculated using appropriate formulae. The absolute sum (positive and negative) values of nutrient indices generate an additional index called the NBI, nutritional balance index (Walworth and Sumner, 1987).

Leaf nutrient guides/standards

By using mean and standard deviation, five petiole nutrient guides/ranges have been derived, viz., deficient, low, optimum, high and excess, for each nutrient. The optimum nutrient range is the value derived from “mean - 4/3SD (standard deviation) to mean + 4/3SD”. The range “low” was obtained by calculating “mean - 4/3 SD to mean - 8/3SD” and the value below “mean - 8/3 SD” was considered as deficient. The value from “mean + 4/3 SD to mean + 8/3 SD” was taken as high and the value above “mean + 8/3 SD” was taken as excessive (Bhargava and Chadha, 1993).

RESULTS AND DISCUSSION

Leaf nutrients concentration range

The nutrient concentration in leaf varied in different orchards of sapota. Leaf N concentration varied from 1.26 to 1.97%, with a mean of 1.573%, indicating that nitrogen content did not vary much among different gardens. However, N was low in some low-yielding gardens when compared to the optimum value. Variation in leaf potassium concentration was high compared to nitrogen indicating, that, the former may be low in most of the low-yielding gardens. Similarly, among secondary nutrients, calcium and sulphur showed higher variation in their concentration (Table 1). Similar trend was noticed for micronutrients in the entire population.

DRIS ratio norms

DRIS identified forty-five nutrient expressions as diagnostic norms that have a higher variance and low

Table 1. Mean and range of nutrient concentrations in sapota

Nutrient	Range	Mean
N (%)	1.26 – 1.97	1.573
P (%)	0.05 – 0.18	0.099
K (%)	1.00 – 2.05	1.562
Ca (%)	0.21 –0.94	0.566
Mg (%)	0.32 – 0.53	0.421
S (%)	0.14 – 0.42	0.283
Fe (ppm)	59 – 198	119
Mn (ppm)	10 – 47	21
Zn (ppm)	10 – 27	14
Cu (ppm)	2 – 10	05

Table 2. DRIS ratio norms for sapota

Selected	ratios Norms	C.V.%	Selected ratios	Norms	C.V%
P/N	0.063	32	K/Cu	0.365	28
N/K	0.989	14	Ca/Mg	1.292	25
Ca/N	0.340	29	Ca/S	2.004	30
Mg/N	0.264	16	Fe/Ca	228.6	46
S/N	0.178	29	Ca/Mn	0.028	38
Fe/N	71.71	33	Ca/Zn	0.039	28
Mn/N	13.69	41	Ca/Cu	0.121	40
N/Zn	0.117	14	S/Mg	0.666	19
N/Cu	0.354	25	Fe/Mg	274.7	35
P/K	0.062	32	Mg/Mn	0.022	32
Ca/P	6.067	51	Mg/Zn	0.031	16
Mg/P	4.543	31	Mg/Cu	0.093	28
S/P	3.043	40	Fe/S	434.5	46
Fe/P	1219	39	S/Mn	0.014	35
P/Mn	0.005	40	Zn/S	53.94	36
Zn/P	152.7	34	S/Cu	0.063	37
P/Cu	0.022	38	Fe/Mn	5.892	45
Ca/K	0.336	32	Fe/Zn	8.386	38
Mg/K	0.258	13	Fe/Cu	25.28	41
S/K	0.173	27	Zn/Mn	0.730	34
Fe/K	70.44	36	Mn/Cu	4.862	48
Mn/K	13.34	41	Zn/Cu	3.102	30
Zn/K	8.609	19	—	—	—

coefficient of variation between high-and low-yielding populations (Table 2). Going by basic principles, N/K (0.989), Mg/N (0.264), N/Zn (0.117), Mg/K (0.258), Zn/K (8.609), S/Mg (0.666), Mg/Zn (0.031), involving macro- and micronutrients which have shown lower CV values compared to others, were selected and these ratios might have a greater physiological rationale. Potassium is known to play a key role in N uptake and translocation, whereas Mg and N are vital constituents of chlorophyll (Raghupathi *et al*, 2004). Hence, maintaining correct ratios of these nutrients is obviously important for the quantum of yield in any crop. Maintaining the ratios of some expressions at optimum when they were with large coefficient of variation was much less critical for performance of the crop. Therefore, nutrients considered as yield-building components, need to be maintained in a state of relative balance for each to be utilized with maximum efficiency for dry matter/yield production (Anjaneyulu, 2006).

DRIS indices and NBI

In Table 3, DRIS indices are presented along with the order in which nutrients limited yield. Thus, DRIS simultaneously identified imbalances, deficiencies and excesses in crop nutrients and ranked them in order of importance. DRIS index is a mean of the deviations of ratios containing a given nutrient, from their respective normal or optimum values. As the value of each ratio function was added to one index sub-total and subtracted from another prior to averaging, all indices were balanced around zero. Thus, the nutrient indices that sum up to zero indicate an optimum level, negative values as relative deficiency and positive values as relative excess of that particular nutrient (Mourao Filho, 2004). The absolute sum values of the nutrient indices generated an additional index called the Nutritional Balance Index (NBI) which indicated an overall imbalance of nutrients in each low-yielding orchard, based on the sum of indices, irrespective of sign. Higher the NBI, larger is the plant nutritional imbalance and thus, lower the yield. The yield-limiting nutrients differed from garden to garden, though some of the nutrients were more prominent. Thus, diagnosis of nutrient imbalance through DRIS indices indicated the most yield-limiting nutrient was potassium followed by nitrogen among major nutrients, and, copper and zinc, among micronutrients. Copper was usually not a yield-limiting factor in many fruit crops such as grape, mango, etc. in these areas. However, copper was observed to be a yield limiting factor in most of the low-yielding sapota gardens (Table 3) after potassium, as these gardens did not receive copper fungicidal sprays for disease management.

Leaf nutrient standards

By using mean and standard deviation, five leaf nutrient guides/ranges have been derived as deficient, low, optimum, high and excess, for each nutrient (Table 4). Optimum leaf N for sapota ranged from 1.60 to 1.85%, whereas, the optimum P range was low, indicating a lower requirement of P compared to N. It was observed that P

Table 3. Diagnosis of nutrient imbalance in low =yielding sapota gardens

		Most limiting				Optimum		Excess		NBI
K-269	Cu-149	Zn-120	Mn-84	S-38	P12	Fe86	Mg101	N111	Ca350	(Sum)1320
K-196	Cu-99	Zn-57	Mn-54	N-3	P23	S41	Fe57	Mg82	Ca206	818
K-162	Cu-91	Zn-77	N-27	S9	Mn10	P16	Fe52	Mg68	Ca202	714
K-306	Cu-181	Mn-120	N-83	Zn-77	Mg56	S78	Ca123	Fe223	P287	1534
K-359	Zn-130	N-99	Cu-44	Ca19	S33	P36	Mg48	Fe157	Mn339	1264
K-280	N-89	Mn-76	Zn-12	P40	Mg50	Cu51	S72	Ca73	Fe171	914
K-206	Mn-179	Cu-113	N-5	Ca 46	P46	Zn48	Mg49	S139	Fe175	1006
K-83	Cu-78	S-77	P-17	N1	Zn6	Mg14	Fe36	Ca47	Mn151	510

Table 4. Leaf nutrient standards for sapota cv. Cricketball

Nutrient	Deficiency	Low	Optimum	High	Excess
N (%)	<1.34	1.34 – 1.59	1.60 – 1.85	1.86 – 2.12	>2.12
P (%)	<0.06	0.06 – 0.09	0.10 – 0.13	0.14 – 0.17	>0.17
K (%)	<1.40	1.40 – 1.62	1.63 – 1.85	1.86 – 2.10	>2.10
Ca (%)	<0.32	0.32 – 0.53	0.54 – 0.74	0.75 – 0.97	>0.97
Mg (%)	<0.36	0.36 – 0.41	0.42 – 0.47	0.48 – 0.53	>0.53
S (%)	<0.19	0.19 – 0.27	0.28 – 0.37	0.38 – 0.46	>0.46
Fe (ppm)	<65	65 – 112	113 – 161	162– 210	>210
Mn (ppm)	<11	11 – 20	21 – 31	32 – 42	>42
Zn (ppm)	<10	10 –13	14 – 17	17 – 21	>21
Cu (ppm)	<03	3 - 4	5 – 7	8 – 10	>10

was generally much less a limiting factor in sapota production. Requirement for K is always next only to nitrogen, as this nutrient is involved not only in production but also in improving the quality of sapota. Among the gardens surveyed, calcium and magnesium status of many individual gardens was optimum compared to their optimum ranges. Similarly, sulphur was not a yield-limiting factor in most of the gardens. Among micronutrients, copper and zinc were found to be deficient in most of the low-yielding gardens. The concentration of copper was as low as 2 ppm and zinc 10 ppm in many low-yielding gardens. However, iron and manganese were low only in very few gardens. It can be concluded that yield-limiting nutrients in sapota gardens can be corrected by following efficient fertilizer application based on leaf nutrient norms developed.

REFERENCES

Anjaneyulu, K. 2006. Development of diagnostic leaf nutrient norms and identification of yield limiting nutrients using DRIS in rose grown under protected conditions. *J. Hort. Sci.,* **1**:28-32

Anonymous. 2004. Horticulture - *Heralding a Golden Revolution*, Dept. Agri. and Co-op., Ministry of Agriculture, Government of India

Beaufils, E. R. 1973. Diagnosis and recommendation integrated system (DRIS). *Soil Sci. Bull.* **1**:1-132 University of Natal Pitermariburg, South Africa

Bhargava, B. S. and Chadha, K. L.1993. Leaf nutrient guides for fruit crops. In: Advances in Horticulture-Fruit Crops, Vol. 2, pp 973-1030. Chadha, K. L. and Pareek, O. P. (eds), Malhotra Publ. House, New Delhi

Bhargava, B. S. and Raghupathi, H. B. 1995. Current status and new norms of nitrogen nutrition for grapevine (*Vitis vinifera*). *Ind. J. Agril. Sci*., **65**:165-169

Jackson, M. L.1973. Soil Chemical Analysis, Prentice Hall of India, New Delhi. pp 498

Letzsch, W. S and Sumner, M. E.1984. Effect of population size and yield level in selection of DRIS norms. *Commun. Soil Sci. Pl. Analysis*, **15**:997-1006

Mourao Filho, F. A. A. 2004. DRIS: Concepts and Applications on nutritional diagnosis in fruit crops. *Sci. Agri*. (Piracicaba,Braz.), **61**:550-560

Raghupathi, H. B., Reddy, Y. T. N., Kurian,Reju and Bhargava, B. S. 2004. Diagnosis of nutrient imbalance in mango by DRIS and PCA approaches. *J. Pl. Nutrition*, **27**:1131-1148

Walworth, J. L. and Sumner, M. E. 1987. The diagnosis and recommendation integrated system. In: *Adv. Soil Sci*., **6**:149-188

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