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Preliminary the Diagnosis and Recommendation Integrated System (DRIS) Norms for Evaluating the Nutritional Status of Mango

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A B S T R A C T

Diagnosis and recommendation integrated system (DRIS) norms were computed from the data on leaf mineral composition, soil available nutrients, and corresponding mean fruit yield of three years (2016–2019), collected from the set of 50 irrigated commercial 'Dashehari' mango orchards, representing 2 locations and 3 basalt derived soil orders (Entisols, Inceptisols, and Vertisols) rich in smectite minerals. The DRIS norms derived primarily index leaves sampled during month of March-April (6–8 months old) suggested optimum leaf macronutrient concentration (%) as: 1.10–2.25 nitrogen (N), 0.09–0.25 phosphorus (P), 0.19–0.45 potassium (K), 1.80–2.45 calcium (Ca), and 0.42–1.01 magnesium (Mg). While, optimum level of micronutrients (ppm) was determined as: 10.60–28.50 zinc (Zn), 101.20–310.50 iron (Fe), 10.50–24.70 copper (Cu), and 69.90–193.90 manganese (Mn) in relation to fruit yield of 30.50–84.69 kg $tree^{-1}$. The data were divided into high-yielding (>50 kg/tree) and low-yielding (<50 kg/tree) subpopulations and norms were computed using standard DRIS procedures and a preliminary DRIS norms for mango growing in the Akhnoor and Samba district are selected. These norms were developed with data from only one region, so data from future surveys and field trials may subsequently be used to enlarge the database allowing the refinement of model parameters. The results elucidate that the DRIS model for mango, developed in this study, is a diagnostic tool that may be used to predict if insufficiencies or imbalances in N, P, K Ca, Mg, Zn, Fe, Cu and Mn supplies are occurring in mango production.

Keywords

Mango, DRIS norms, Yield, Nutrient contents, Leaf diagnosis

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Introduction

Horticultural crops (fruits 96754000 metric tonnes and vegetables 187474000 metric tonnes) in India occupy 9% of the cultivated area but account for about 6% of the fertilizer used as per production statistics of NHB for 2018-19. In the chief horticultural crops like Mango (*Mangifera indica*) fertilizers input represents a significant portion of its production cost, so, constant evaluation and calibration of the fertilizer programs in this crop is necessary, which may be supported by nutritional diagnosis. The Diagnosis and Recommendation Integrated System (DRIS) is a method to evaluate plant nutritional status that uses a comparison of the leaf tissue nutrient concentration ratios of nutrient pairs with norms from a high-yielding group (Soltanpour *et al*., 1995). The first step to implement DRIS or any other foliar diagnostic system is the establishment of standard values or norms (Walworth & Sumner, 1987; Bailey *et al*., 1997). In order to establish the DRIS norms, it is necessary to use a representative value of leaf nutrient concentrations and respective yields to obtain accurate estimates of means and variances of certain nutrient ratios that discriminate between high- and low-yielding groups.

This is done using a survey approach in which yield and nutrient concentration data are collected from commercial crops and/or field experiments from a large number of locations (Bailey *et al*., 1997) to form a databank. In the present investigation, the pivot crop was Mango (*Mangifera indica* L.) growing in the Akhnoor and Samba districts of Jammu DRIS was used for monitoring nutrients status of the crop in these districts and these two districts happen to be the main mango producing areas in Jammu regions. An attempt was also made to derive sufficiency ranges from nutrient indexing survey of mango fruit trees.

Materials and Methods

The present experiment was conducted at farmer's field under the aegis of, Division of Fruit Science, Faculty of Agriculture, Chatha, Sher-e- Kashmir University of Agricultural Sciences and Technology of Jammu during two consecutive years of 2018-19 and 2019-2020. The research was carried out in the in Akhnoor and Samba which are the main mango producing areas in Jammu regions. Akhnoor and Samba lying between 33^0 05' 06" to 32^0 30' 987" North of equator and 75^0 02' 861" East of prime meridian. The sub-tropical region falls between 300 to 1000 m above mean sea level with extreme summer having temperature as high as 46^0 C (115^0 F) while, temperatures in the winter month occasionally falls below 4^0 C (39^0 F).

Average yearly precipitation is about 42 inches (1,100 mm) with the bulk of rainfall in the month from June to September. Fifty mango orchards were selected in these areas of Jammu region. Among these, twenty-eight orchards were selected in Akhnoor and twenty-two were selected in Samba. At each location well established mango orchards were selected.

At each location well established mango orchards were selected. Representative leaf samples comprising of 25-30 leaves (latest mature flush from middle of the terminal growth) were collected from 8-10 randomly selected trees in each selected orchard as per the sampling time i.e.15^{th} June- 15^{th} July. The leaf samples were washed with ordinary water and then with 0.1N hydrochloric acid (HCL), followed by washing with distilled water. The washed leaf samples were surface dried and then oven dried at ± 70^0 for 48 hours till constant weight obtained.

Further the dried leaf samples were grounded using Wiley grinding machine to pass through a 60 mesh stainless steel sieve to obtain homogenous samples. The samples were stored in labeled air tight amber coloured glass bottles till further estimation. Total Nitrogen (N) was analyzed by the Nessler procedure (Chapman and Pratt, 1961). Phosphorus (P) was analyzed by the Vando-molybdo phosphoric acid yellow colour method. (Jackson 1973.) Potassium (K) was measured by the flame photometer (Piper 1944). Calcium (Ca), Magnesium (Mg), Copper (Cu), iron (Fe), Manganese (Mn) and Zinc (Zn) were measured by atomic absorption spectrophotometer (Cottenie *et al.*, 1979).

According to Beaufils (1973) and Walworth and Sumner (1987), the DRIS norms selection was made along the following priorities: Yield and leaf nutrient concentrations built a databank, which was divided into high yielding (>50 kg/tree) and low yielding (<50 kg/tree) sub populations. Calculate the mean, standard deviation, variance and skew for each leaf nutrient concentration for the two subpopulations. Calculate a variance ratio (V_{low} for low-yielding sub-population /V_{high} for high-yielding sub-population) for each nutrient concentration and of two ratios involving each pair of nutrients. Select nutrient expressions for which the variance ratios (V_{low}/V_{high}) were relatively large. Select equal numbers of expressions for each of the n elements (A, B, C… and X) to meet an absolute (orthogonal) requirement of the mathematical model. The following equations were developed for the calculation of DRIS indexes based on leaf analysis:

$$\text{N index} = \frac{f(N/P)+f(NxK)+f(N/S)-f(Ca/N)+f(N\times Mg)-f(Zn/N)+f(N/Fe)-f(Cu/N)+f(N/Mn)}{9}$$

$$P/N > p/n, \text{ then } f(P/N) = [\{(P/N) / (p/n)\}-1] \times (1000/CV)$$

or, when

$$P/N < p/n, \text{ then } f(P/N) = [1-\{(p/n)/(P/N)\}] \times (1000/CV)$$

In these, P/N is the value of the ratio of the two elements in the tissue of the plant being diagnosed (test data), p/n is the optimum value (mean of high yielders) of norm for that ratio, CV is the Coefficient of variation associated with the norm and z is the number of functions comprising the nutrient index. The procedure adopted for calculating the values of other functions such as f (N/K), f (P/K) etc., was same as adopted for calculation of f (P/N), using appropriate norms and CV.

Results and Discussion

Summary statistics for the leaf nutrient concentration and fruit yield of mango data are given in Table 1. Twenty eight (28) out of fifty (50) data points were assigned to the high yielding sub population (> 50 kg/tree). The yield data ranged from 30.50 kg/tree to 84.69 with a mean value of 55.55 kg/tree in the full population. Binary nutrient ratio combinations of all nutrients were therefore calculated, and the mean, coefficient of variation, variance of all nutrients ratio of the high- ($v^2{}_h$) and low yielding population ($v^2{}_l$) and the variance ratio between the low and high yielding population ($v^2{}_l/v^2{}_h$) ratio are calculated (Table 2). DRIS norms established for mango crop should be useful to evaluate mango nutritional status and to calibrate fertilizer programs, but they must be validated before mango grower adopts them. On the basis of the variance ratios ($V^2{}_l$ / $V^2{}_h$) the nutrient expression having the large variance ratio was taken as a norm (diagnostic ratio) for such binary nutrient balance, the expression having the lower variance ratio, however, stood out and skewed from selection.

The selection of a nutrient ratio as DRIS norms (i.e. N/P or P/N) is indicated by the $V2_l/V2_h$ ratio (Hartz *et al.*, 1998). The higher $V^2{}_l/V^2{}_h$ ratio, the more specific the nutrient ratio must be in order to obtain a high yield (Payne *et al.*, 1990). Although Beaufils (1973) suggests that every parameter which shows a significant difference of variance ratio between the two populations under comparison (low and high yielding) should be used in DRIS, other researchers have adopted the ratio which maximized the variance ratio between the low and high yielding populations (Payne *et al*., 1990 and Hundal *et al*., 2005). The aim of this procedure is to determine the norms with the greatest predictive precision (Caldwell *et al*., 1994). The discrimination between nutritionally healthy and unhealthy plants is maximized when the ratio of variances of low versus high yielding populations is also maximized (Gustave *et al*., 2011).

As pointed by Bailey *et al*., (1997), DRIS norms (nutrient ratios) with large V^2_l/V^2_h ratios and small coefficient of variation imply that the balance between these specific pairs of nutrients could be of critical importance for crop production. Therefore, nutrient ratios with large V^2_l/V^2_h ratio and small coefficient of variation indicate that the obtainment of high yield should be associated to small variation around the average nutrient ratio. There is a speculation that the large V^2_l/V^2_h ratio and the small CV found for specific ratios between nutrients probably imply that the balance between these pairs of nutrients could be important to mango fruit production.

So, the DRIS model for mango, developed in this study, is a diagnostic tool that may be used to predict if insufficiencies or imbalances in N, P, K, S, Ca, Mg, Zn, Fe, Cu and Mn supplies which are occurring in mango production area. DRIS indexes are still in developing stage. The criteria for the reference subpopulation definition also demand further studies. There are several ways to select the reference population, but there is no common and standard. Further investigation and field experiments are necessary, to enlarge the model database and allow the refinement of DRIS parameters.

Table.1 Summary statistics for mango yield and leaf nutrient concentration data for total (n=50) and high- yielding subpopulations (n=26)

Parameters	Total population(n=50)					High yielding sub-population				
	Mean	Med	Max	Min	Skew	Mean	Med	Max	Min	Skew
Fruit yield kg ha^{-1}	55.55	46.38	84.69	30.50	1.87	67.21	51.75	84.69	50.30	3.83
Nutrients										
N	1.97	2.04	2.25	1.10	-0.75	2.12	2.14	2.25	1.77	-0.55
P	0.17	0.16	0.25	0.09	0.75	0.19	0.18	0.25	0.15	1.54
K	0.30	0.28	0.45	0.19	0.75	0.34	0.33	0.45	0.20	0.44
Ca	2.11	2.12	2.45	1.80	-83.14	2.21	2.18	2.45	1.98	1.99
Mg	0.64	0.60	1.01	0.42	28.31	0.73	0.69	1.01	0.49	1.05
S	0.18	0.20	0.29	0.04	7.76	0.21	0.21	0.29	0.12	0.06
Zn	21.19	20.5	28.50	10.60	0.52	23.32	22.35	17.60	2.45	1.05
Fe	209.44	212.7	310.50	101.20	-0.16	249.01	222.4	310.50	192.20	1.96
Cu	18.50	20.5	24.70	10.50	-1.80	19.63	18.45	24.70	16.40	1.65
Mn	132.15	131.8	193.90	69.90	0.07	150.48	143.6	193.90	116.20	0.98

Table.2 Mean, coefficient of variation and variances of various nutrient expressions for macro and micro nutrients in low and high yielding populations of mango orchards

Nutrient ratios	High yielding population			Low yielding population			V^2_l/V^2_h	Selected ratios
	Mean	CV	variance	Mean	CV	variance		
N/P	12.761	16.814	4.60363094	11.074	11.962	1.75464638	2.62	√
P/N	0.080	15.980	0.00016499	0.722	12.007	0.00012085	1.37	
N/K	7.238	16.002	1.34159930	1.045	21.173	1.87397928	0.72	
N×K	0.475	37.686	0.03206100	0.005	22.455	0.02625301	1.22	√
N/S	16.476	43.993	52.53858652	10.248	18.365	3.54193907	14.83	√
S/N	0.072	40.037	0.00082161	0.100	15.648	0.00024623	3.34	
N/Ca	0.899	12.557	0.01273612	0.959	4.081	0.00153192	8.39	
Ca/N	1.133	15.034	0.02901588	1.045	4.305	0.00202217	14.48	√
NxMg	1.007	37.702	0.14423849	1.559	24.546	0.1464510	0.98	√
N/Zn	974.939	13.175	16498.8923072	915.693	9.440	7471.6200265	1.79	
Zn/N	0.001	18.502	0.00000004	0.001	9.585	0.00000001	2.17	√
N/Fe	113.818	20.387	538.41935467	86.679	13.993	147.10370973	3.22	√
Fe/N	0.009	19.441	0.00000314	0.012	13.510	0.00000252	1.09	
N/Cu	1082.204	19.922	46479.7535985	1087.003	10.106	12066.394722	3.85	
Cu/N	0.001	24.317	0.00000006	0.001	10.709	0.00000001	5.58	√
N/Mn	164.303	16.815	763.2722857	142.609	11.853	285.70403301	2.67	√
Mn/N	0.006	15.999	0.00000100	0.007	11.824	0.00000071	1.41	
P/K	0.573	12.746	0.00532553	0.590	24.383	0.02070958	0.26	
P*K	0.038	43.795	0.00028105	0.066	27.599	0.00033610	0.84	√
P/S	1.332	47.745	0.40450416	0.930	16.093	0.02238403	18.07	√
S/P	0.919	44.748	0.16901521	1.102	15.572	0.02942910	5.74	
P/Ca	0.072	17.662	0.00016088	0.088	11.392	0.00009977	1.61	
Ca/P	14.356	18.137	6.77899895	11.553	11.794	1.85632727	3.65	√
P/Mg	0.271	17.392	0.00222722	0.273	19.238	0.00274825	0.81	
Mg/P	3.787	16.933	0.41116520	3.783	17.267	0.42663956	0.96	√
P/Zn	78.668	22.218	305.48736119	83.625	13.174	121.37138802	2.52	
Zn/P	0.013	28.193	0.00001441	0.012	14.199	0.00000299	4.82	√
P/Fe	9.092	23.798	4.68222256	7.898	15.903	1.57775298	2.97	√
Fe/P	0.115	21.896	0.00063954	0.129	14.902	0.00037217	1.72	
P/Cu	87.495	28.354	615.47420444	99.161	12.966	165.30225071	3.72	
Cu/P	0.012	32.144	0.00001592	0.010	13.803	0.00000200	7.94	√
P/Mn	12.876	0.171	0.00048311	12.881	1.172	0.02279666	0.02	
P*Mn	0.002	42.465	0.00000052	0.003	27.953	0.00000069	0.75	√
K/S	2.282	41.623	0.90197893	1.626	20.622	0.11248491	8.02	√
S/K	0.508	37.882	0.03697588	0.641	20.965	0.01806603	2.05	
K/Ca	0.126	16.970	0.00045864	0.154	17.713	0.00073996	0.62	
Ca/K	8.132	16.117	1.71787353	6.736	20.082	1.82974305	0.94	√
K/Mg	0.473	8.398	0.00157625	0.475	21.323	0.01027263	0.15	
K*Mg	0.144	49.588	0.00513227	0.253	33.060	0.00698771	0.73	√
K/Zn	137.210	18.330	632.56606628	146.792	20.271	885.42395790	0.71	
Zn/K	0.008	20.744	0.00000245	0.007	22.204	0.00000249	0.98	√
K/Fe	15.851	19.317	9.37529137	13.784	19.567	7.27453220	1.29	√

Fe/k	0.065	15.782	0.00010497	0.075	18.890	0.00020138	0.52	
K/Cu	152.245	23.052	1231.71612679	173.757	18.836	1071.2232020	1.15	
Cu/k	0.007	27.110	0.00000357	0.006	22.530	0.00000182	1.96	√
K/Mn	22.864	13.981	10.21855683	22.779	18.875	18.48617612	0.55	
K*Mn	0.003	43.846	0.00000170	0.005	27.378	0.00000199	0.85	√
S/Ca	0.065	45.829	0.00089994	0.096	15.192	0.00021287	4.23	
Ca/s	18.992	50.142	90.68616904	10.691	18.278	3.81866243	23.75	√
S/Mg	0.237	34.882	0.00685552	0.295	14.769	0.00189803	3.61	
Mg/S	4.823	42.082	4.11921680	3.457	13.942	0.23236111	17.73	√
S/Zn	68.601	38.908	712.43953579	91.445	14.922	186.19998578	3.83	
Zn/S	0.017	39.758	0.00004508	0.011	21.269	0.00000574	7.85	√
S/Fe	7.811	34.217	7.14398103	8.625	17.199	2.20034998	3.25	
Fe/S	0.144	38.390	0.00305986	0.119	18.102	0.00046696	6.55	√
S/Cu	76.585	42.396	1054.22478414	108.609	16.588	324.57351124	3.25	
Cu/S	0.016	50.241	0.00006301	0.009	19.040	0.00000326	19.30	√
S/Mn	11.828	44.738	28.00300410	14.187	15.486	4.82655536	5.80	
Mn/S	0.103	47.738	0.00243893	0.072	15.947	0.00013244	18.41	√
Ca/Mg	3.823	13.950	0.28436740	3.125	18.323	0.32790362	0.87	√
Mg/Ca	0.267	16.041	0.00183813	0.329	16.330	0.00289225	0.64	
Ca/Zn	1100.241	19.308	45126.4800951	955.608	9.535	8301.8586910	5.44	√
Zn/Ca	0.001	16.507	0.00000002	0.001	9.338	0.00000001	2.46	
Ca/Fe	128.928	23.788	940.58710852	90.283	12.378	124.87711746	7.53	√
Fe/Ca	0.008	25.092	0.00000425	0.011	12.086	0.00000184	2.30	
Ca/Cu	1213.124	20.725	63212.9241262	1133.510	9.477	11540.128455	5.48	√
CU/Ca	0.001	20.156	0.00000003	0.001	9.435	0.00000001	4.24	
Ca/Mn	184.834	18.120	1121.69923557	148.785	11.755	305.88685139	3.67	√
Mn/Ca	0.006	17.643	0.00000097	0.007	11.275	0.00000059	1.64	
Mg/Zn	290.166	16.484	2287.67638699	312.911	15.141	2244.5547992	1.02	
Zn/Mg	0.004	18.261	0.00000042	0.003	18.161	0.00000036	1.18	√
Mg/Fe	33.601	18.962	40.59489258	29.338	12.562	13.58252246	2.99	√
Fe/Mg	0.031	14.827	0.00002052	0.035	13.172	0.00002080	0.99	
Mg/Cu	320.713	19.913	4078.48054399	374.377	20.296	5773.7440925	0.71	
Cu/Mg	0.003	22.614	0.00000054	0.003	22.511	0.00000039	1.37	√
Mg/Mn	48.756	16.929	68.12554954	48.726	17.342	71.40569398	0.95	√
Mn/Mg	0.021	17.333	0.00001334	0.021	19.191	0.00001648	0.81	
Zn/Fe	0.119	23.986	0.00080912	0.095	12.156	0.00013299	6.08	√
Fe/Zn	8.830	20.070	3.14038920	10.691	12.166	1.69190597	1.86	
Zn/Cu	1.112	16.442	0.03344120	1.195	12.117	0.02095409	1.60	
Cu/Zn	0.923	16.763	0.02394766	0.849	12.452	0.01118038	2.14	√
Zn/Mn	0.173	28.183	0.00238702	0.157	14.181	0.00049430	4.83	√
Mn/Zn	6.110	22.217	1.84267121	6.492	13.085	0.72165751	2.55	
Fe/Cu	9.783	24.258	5.63234009	12.78	16.019	4.1705081	1.35	
Cu/Fe	0.109	28.496	0.00096720	0.080	16.116	0.00016789	5.76	√
Fe/Mn	1.487	21.896	0.10602335	1.668	15.033	0.06284666	1.69	
Mn/Fe	0.706	23.798	0.02824309	0.613	15.947	0.00956526	2.95	√
Cu/Mn	0.160	32.088	0.00262972	0.132	13.833	0.00033405	7.87	√
Mn/Cu	6.794	28.298	3.69682941	7.699	12.921	0.98947260	3.74	

As it stands, though, this preliminary DRIS model for mango is one of the best diagnostic tools currently available for simultaneously evaluating the N, P, K, S, Ca, Mg, Zn, Fe, Cu and Mn status of mango trees in the Akhnoor and Samba district of Jammu region and indeed elsewhere in the other mango production areas with similar climatic and soil conditions.

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