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

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Abstract
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

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 region. 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° 05' 06" to 32° 30' 987" North of equator and 75° 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°C (115°F) while, temperatures in the winter month occasionally falls below 4°C (39°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<sup>th</sup> June- 15<sup>th</sup> 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°C 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-molybdophosphoric 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 ($V_{\text{low}}$ for low-yielding sub-population /$V_{\text{high}}$ 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 ($V_{\text{low}}$/$V_{\text{high}}$) 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:

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

or, when

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

and the variance ratio between the low and high yielding population ($V_{\text{low}}^2$/$V_{\text{high}}^2$) 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 ($V_{\text{low}}^2$ / $V_{\text{high}}^2$) 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.

**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- ($V_{\text{h}}^2$) and low yielding population ($V_{\text{l}}^2$) and the variance ratio between the low and high yielding population ($V_{\text{low}}^2$/$V_{\text{high}}^2$) 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 ($V_{\text{low}}^2$ / $V_{\text{high}}^2$) 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.
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 | $V^2/V^2_h$ | 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 |
| NxK             | 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 | 1206.6394722 | 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 | 285.7043301 | 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 | 1.57775296 | 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 |
| K/Fe            | 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/Fe           | 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 | √ |
| Parameter | Value   |
|-----------|---------|
| Fe/k      | 0.065   |
| K/Cu      | 152.245 |
| Cu/k      | 0.007   |
| K/Mn      | 22.864  |
| K*Mn      | 0.003   |
| S/Ca      | 0.065   |
| Ca/s      | 18.992  |
| S/Mg      | 0.237   |
| Mg/Sg     | 4.823   |
| S/Zn      | 68.601  |
| Zn/S      | 0.017   |
| S/Fe      | 7.811   |
| Fe/Ss     | 0.144   |
| S/Cu      | 76.585  |
| Cu/S      | 0.016   |
| S/Mn      | 11.828  |
| Mn/S      | 0.103   |
| Ca/Mg     | 3.823   |
| Mg/Na     | 0.267   |
| Ca/Zn     | 110.241 |
| Zn/Ca     | 0.001   |
| Ca/Fe     | 128.928 |
| Fe/Ca     | 0.008   |
| Ca/Cu     | 1213.124|
| Cu/Ca     | 0.001   |
| Ca/Mn     | 184.834 |
| Mn/Ca     | 0.006   |
| Mg/Zn     | 290.166 |
| Zn/Mg     | 0.004   |
| Mg/Fe     | 33.601  |
| Fe/Mg     | 0.031   |
| Mg/Cu     | 320.713 |
| Cu/Mg     | 0.003   |
| Mg/Mn     | 48.756  |
| Mn/Mg     | 0.021   |
| Zn/Fe     | 0.119   |
| Fe/Zn     | 8.830   |
| Zn/Cu     | 1.112   |
| Cu/Zn     | 0.923   |
| Zn/Mn     | 0.173   |
| Mn/Zn     | 6.110   |
| Fe/Cu     | 9.783   |
| Cu/Fe     | 0.109   |
| Fe/Mn     | 1.487   |
| Mn/Fe     | 0.706   |
| Cu/Mn     | 0.160   |
| Mn/Cu     | 6.794   |
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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