The Diagnosis and Recommendation Integrated System (DRIS) for evaluating cationic micronutrients of mulberry (*Morus sp.*) growing under Darjeeling hills

R. Kar[1], S. Chatterjee[2], M. K. Ghosh[1], S. K. Dutta[1] and S. Nirmal Kumar[1]

[1]Soil Science and Chemistry Section, Central Sericultural Research and Training Institute, Central Silk Board, Berhampore-742101, West Bengal, India
ranjitkr4@gmail.com
[2]Regional Sericultural Research Station, Central Silk Board, Kalimpong, Darjeeling, West Bengal, India

Abstract: A regional survey was carried out in 78 selected gardens of mulberry (*Morus sp.*) growing under Darjeeling hills of West Bengal. The diagnostic norms developed using Diagnosis and Recommendation Integrated System (DRIS) was employed to ascertain optimum foliar concentration of cationic micronutrients for mulberry under the study. Foliar concentrations of cationic micronutrients from the said mulberry gardens were analyzed to compute DRIS indices. Regression analysis was used to fit a model relating DRIS indices to foliar concentrations of the micronutrients. There was a positive and significant relationship between foliar micronutrient concentrations of mulberry and DRIS indices. The optimum foliar concentrations of cationic micronutrients for mulberry growing under hills of Darjeeling are 10.55 mg kg^{-1} for Zn, 2.85 mg kg^{-1} for Cu, 68.97 mg kg^{-1} for Fe and 40.73 mg kg^{-1} for Mn, respectively. DRIS norms evaluated are useful to correct nutritional imbalances and to increase mulberry yield.
[R. Kar, S. Chatterjee, M. K. Ghosh, S. K. Dutta and S. Nirmal Kumar. **The Diagnosis and Recommendation Integrated System (DRIS) for evaluating cationic micronutrients of mulberry (*Morus sp.*) growing under Darjeeling hills.** *Nat Sci* 2015;13(5):110-114]. (ISSN: 1545-0740). http://www.sciencepub.net/nature. 14

Key words: Cationic micronutrients, DRIS indices, foliar concentration, mulberry

1. Introduction:

Foliar analysis is usually considered to be an important tool to monitor the nutrient status of plants (Hundal *et al*., 2008). The Diagnosis and Recommendation Integrated System (DRIS) deals with the ratios of concentration, rather than the concentration of individual nutrients to interpret leaf tissues analysis (Sumner, 1978). The nutrient ratios generally remained consistent due to dilution or increased concentrations at different stages of growth. Plant-tissue analysis can be interpreted successfully through the employment of DRIS norms (Hundal and Arora, 1996; Reis Junior and Monnerat, 2003). The very system makes multiple two-way comparisons between the levels of various plant nutrients and integrates these comparisons into a series of nutrient indices (Walworth *et al*., 1986). Excessive (positive indices), adequate (zero indices) or deficient (negative indices) level of any nutrient in plant can be determined by this model. DRIS norms designate a system for use with a crop involves compiling a database (Payne *et al*., 1990) from which optimum ratios for all nutrient combinations are determined (Synder *et al*., 1989).

Hills of Darjeeling has been sustaining as the principal seed crop zone for mulberry sericulture in Eastern India (Datta, 2000). Soils of this zone come under the broad group *brown forest soils* (Mandal and Roy, 1985) and nutrient availability of the same is suffering from the problem of sluggish humification (Kar *et al*., 1995). However, mulberry cultivation in this zone is already standardized in terms of application of the major nutrients (Bose and Kar, 2010). Unfortunately, no recommendation is available on the application of micronutrients without which balanced nutrition is not possible. It is reported that cationic micronutrients like Zn, Cu, Fe and Mn are substantially deficient in Indian soils (Singh and Behra, 2008). In light of the above, the present investigation has been initiated to work out the strategy for management of cationic-micronutrients in mulberry gardens under Darjeeling hills of West Bengal through the employment of DRIS norms. The relationship between foliar concentrations of the said micronutrients and DRIS indices can be used to make nutritional diagnosis. The optimum foliar concentration of respective cationic micronutrient can be ascertained through the appropriate exercise under the fitted model between micronutrient concentration and respective DRIS index (Reis Junior and Monnerat, 2003).

2. Materials and Methods:

Seventy eight gardens of mulberry (*Morus sp.*) have been selected from hilly areas of Darjeeling district of West Bengal for carrying out the present investigation. Representative soil sample (0-30 cm) from each of the garden was collected following the principle of compositing and was analyzed for estimation of DTPA-extractable Cu, Zn, Fe and Mn contents (Lindsay and Norvell, 1978). A total of two thirty four mulberry leaf samples were collected during three different seasons of a year from the corresponding mulberry gardens. The collected leaf samples were oven dried at $70^{O}C$ to a constant dry weight before being ground in a Willey mill. For estimation of Cu, Zn, Fe and Mn contents of the ground leaf samples, the same were digested with tri-acid mixture (HNO_3: $HClO_4$: H_2SO_4 :: 10: 4: 1) and thereby estimated the said cationic micronutrients' contents of the digested material with the help of Analyst 200, Atomic Absorption Spectrometer of Perkin-Elmer (Jackson, 1973). The results of different seasons were pooled and subjected to computation under DRIS for further evaluation.

Cu, Zn, Fe and Mn concentration in mulberry leaves and corresponding leaf yield were used for calculation of DRIS norms (Hundal and Arora, 1996). As per the requirement of computation under DRIS, micronutrient ratios were enumerated from the status of foliar micronutrient and further, exercised under an orthogonal mathematical model (Hundal *et al.*, 2008) to work out the DRIS functions (f) as follows:

$f(A / B) = [(A / B)/(a / b) – 1] \times 1000/CV$, when $A / B \geq a / b$ …….. (1)

or

$f(A / B) = [1 - (A / B)/(a / b)] \times 1000/CV$, when $A / B < a / b$ …….. (2)

In these equations, A / B is the tissue micronutrient ratio of the plant to be diagnosed, a / b is the optimum value or norm for that given ratio and CV is the coefficient of variation associated with the norm. The computed DRIS functions (f) were further exercised following the norms of Hundal and Arora (1996) to compute the DRIS indices (I) for individual micronutrient, which is the quantitative evaluation of relative degree of imbalance of the micronutrients.

Regression analysis, relating DRIS indices to foliar micronutrient concentrations as independent variable (Reis Junior and Monnerat, 2003), was used for assessment of optimum requirement of foliar micronutrient. The best fitting model was chosen among the linear and logarithm [$y = a + b \ln(x)$] models. The foliar micronutrient content that produces the null DRIS index has been registered as the optimum foliar concentration.

3. Results and Discussion:

Availability of cationic micronutrients in soil

Cationic micronutrients' availability in the mulberry growing soils under Darjeeling hills of West Bengal as furnished in the table-1 is compared with the critical level of DTPA extracted Cu (0.20 mg kg^{-1}), Zn (0.60 mg kg^{-1}), Fe (4.50 mg kg^{-1}) and Mn (2.65 mg kg^{-1}) from soil as per literature available (Lindsay and Norvell, 1978). The comparison indicated that soils of mulberry vegetation under hills of West Bengal was mostly deficient in Mn (65.38%) followed by Zn (25.64%) and there was no deficiency of available Cu or Fe.

Table 1: Cationic micronutrients' availability in mulberry growing soils under Darjeeling hills of West Bengal and their percent deficiency

Micronutrient	Soil availability (mg kg^{-1})		Percent deficiency in soil
	Range	Mean	
Copper	0.31 - 5.40	1.19 ±0.108	-
Zinc	0.04 - 5.11	1.67 ±0.143	25.64
Iron	20.98 - 65.11	44.76 ±1.358	-
Manganese	0.28 - 27.00	4.44 ±0.734	65.38

Optimum requirement of foliar cationic micronutrients for mulberry

Concentrations of Cu, Zn, Fe and Mn in mulberry leaves of different locations as presented in table-2 were used to compute the nutrient expressions like Cu/Zn, Fe/Zn, Mn/Zn etc. for subsequent utilization of the same for calculation of DRIS norms. The nutrient expressions as micronutrient ratios were exercised further following the principle of Hundal *et al.* (2008) to work out the DRIS functions (f) for those micronutrient ratios (Table-3). Quantitative evaluation of relative degree of imbalance of the cationic micronutrient, designated as DRIS indices (I), was computed following the norms of Hundal and Arora (1996) and presented in the same table. A range of negative or positive values was registered by the DRIS indices for individual micronutrient and the same was utilized to determine optimum foliar concentration based on the principle that the yield of mulberry would not be limited by the foliar concentration of cationic micronutrient at null DRIS index (Kar *et al.*, 2014).

Table 2: Cationic micronutrients' contents in mulberry leaves corresponding to soil samples under Darjeeling hills of West Bengal

Micronutrient	Foliar content (mg kg^{-1})	
	Range	Mean
Copper	1.6 - 7.3	3.8 ±0.15
Zinc	4.3 - 36.5	16.3 ±0.79
Iron	7.2 - 124.4	58.6 ±4.13
Manganese	10.9 - 118.8	48.3 ±3.86

Table 3: DRIS functions (*f*) for ratios of cationic micronutrients' contents in mulberry leaves and DRIS index (I) for individual micronutrient under Darjeeling hills of West Bengal

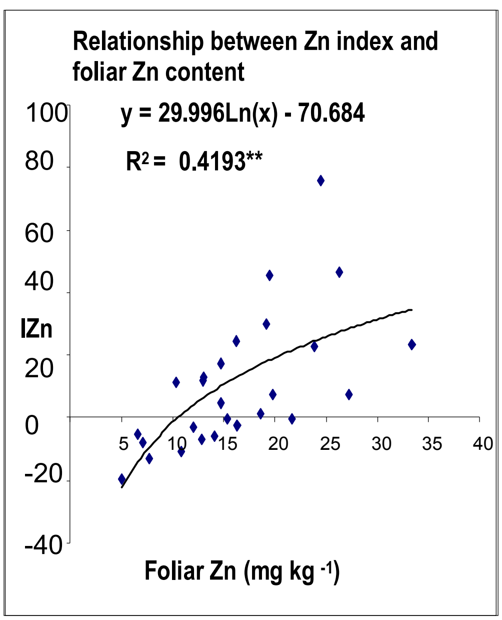
Micronutrient ratios					
Cu/Zn	Fe/Zn	Mn/Zn	Fe/Cu	Mn/Cu	Fe/Mn
0.26±0.02 (0.10-0.41)	4.88±0.95 (0.34-21.56)	3.29±0.44 (0.49-8.00)	17.64±2.41 (1.43-41.46)	13.61±2.05 (2.45-38.90)	1.79±0.34 (0.16-8.62)
DRIS functions (*f*)					
f (Cu/Zn)	*f* (Fe/Zn)	*f* (Mn/Zn)	*f* (Fe/Cu)	*f* (Mn/Cu)	*f* (Fe/Mn)
-46.36 to +29.39	-135.73 to +34.57	-83.78 to +20.96	-162.98 to +19.39	-59.33 to +24.20	-107.33 to +39.27

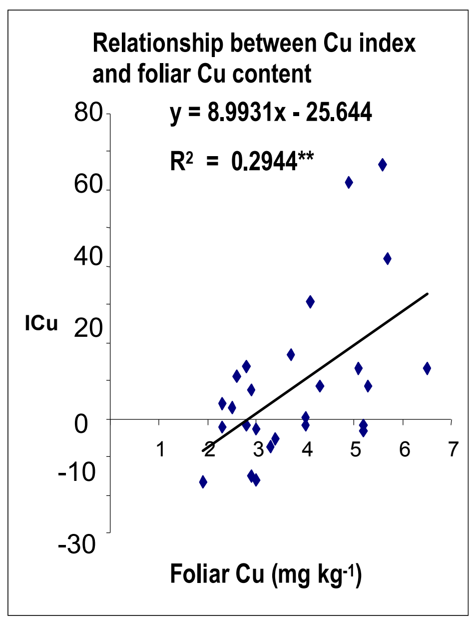
DRIS index (I)			
I_{Cu}	I_{Zn}	I_{Fe}	I_{Mn}
-16.71 to +66.50	-19.78 to +75.95	-104.02 to +31.08	-42.29 to +45.87

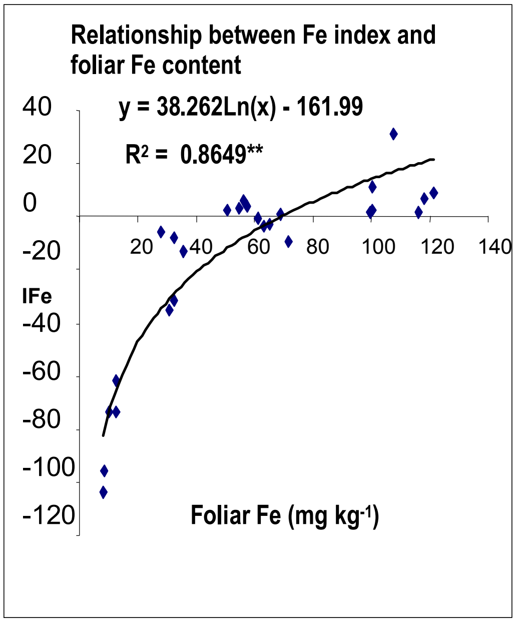
The values of DRIS indices were, further, regressed with corresponding foliar micronutrient concentrations as independent variable under an established model (Reis Junior and Monnerat, 2003). The best fitting model was chosen among the linear and logarithm [y = a + b ln(x)] models. The foliar micronutrient content that produced the null DRIS index was determined as optimum foliar concentration for respective cationic micronutrient and the same is presented schematically in figure I.

Table 4: Optimum requirement and toxic limit of cationic micronutrients for mulberry growing under Darjeeling hills of West Bengal in terms of foliar content

Micronutrient	Regression equation	R^2	Optimum requirement (mg kg^{-1})	Toxic limit (mg kg^{-1})
Copper	y = 8.9931 x – 25.644	0.2944**	2.85	> 7.27
Zinc	y = 29.996 Ln(x) – 70.684	0.4193**	10.55	> 34.97
Iron	y = 38.262 Ln (x) – 161.99	0.8649**	68.97	> 155.93
Manganese	y = 21.628 Ln(x) – 80.174	0.7218**	40.73	>138.63







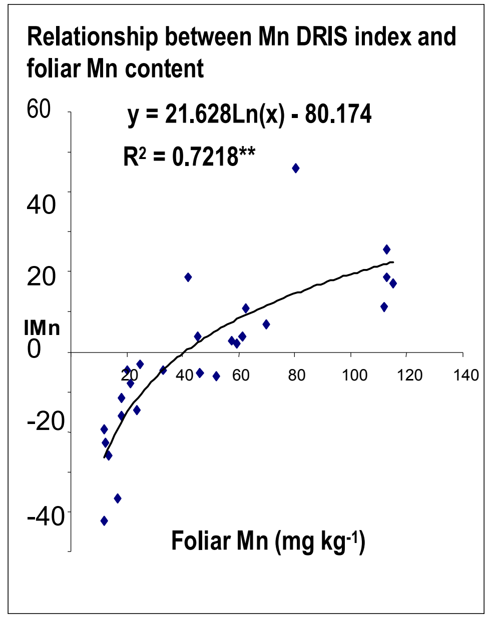


Fig.-I Relationship between DRIS indices of individual micronutrient and respective foliar content under Darjeeling hills of West Bengal

The optimum foliar requirement of different cationic micronutrients, as computed under figure I, is presented in table 4 and the same is found varying with respect to different micronutrients. Besides, toxicity limit of the individual micronutrient in the leaves of mulberry was also derived based on the value expressed as 'micronutrient concentration > mean + 8/3 SD' (Beaufils, 1971; Beaufils and Sumner, 1976; Bhargava, 2002), where SD stands for standard deviation.

Preliminary DRIS norms for Cu, Zn, Fe and Mn in mulberry leaves have been found to be useful in diagnosing deficiency or sufficiency of particular cationic micronutrient based on its optimum requirement and the same, in turn, can help in efficient utilization of micronutrient-fertilizers by using single straight fertilizers rather than fertilizers mixtures or compounds containing more than one element. Optimum requirement and toxicity limit of cationic micronutrients, both the values promise to be of handful for appropriate management of micronutrients in the mulberry garden under hills of Darjeeling. Moreover, conducting of large number of field experiments on different soil types involving tremendous expenditure can be averted on the basis of DRIS derived sufficiency ranges for different cationic micronutrients in conjunction with database pertaining to nutrient indexing survey on soil status of the same.

References

1. Beaufils, E. R. (1971) Physiological diagnosis – A guide for improving maize production based on principles developed for rubber trees, *Fertl. Soc. South Africa J.*, 1: 1-28.
2. Beaufils, E. R. and Sumner, M. E. (1976) Application of DRIS approach in calibrating soil, plant yield and quality factors of sugarcane, *Proc. South Africa Sugar Technol. Assoc.*, 1: 123-127.
3. Bose, P. C. and Kar. R. (2010) *Soil Characteristics and Nutritional Management of Mulberry in Eastern & North-Eastern India.* Central Sericultural Research & Training Institute, Central Silk Board, Printernet, Berhampore, West Bengal.
4. Bhargava, B. S. (2002) Leaf analysis for nutrient diagnosis, recommendation and management in fruit crops, *J. Indian Soc. Soil Sci*., 54: 353-373.
5. Datta, R. K. (2000) Silkworm breeding in India: Present status and new challenges. *Lead paper, National Conference on Strategies for Sericulture Research and Development*. 16-18 November, Mysore, pp. 12-20.
6. Hundal, H. S. and Arora, C. L. (1996) Preliminary micronutrients foliar diagnostic norms for Litchi (Litchi chinensis Sonn) using DRIS, *J. Indian Soc. Soil Sci*., 44: 294-298.
7. Hundal, H. S., Singh, D., Singh, K. and Brar, J. S. (2008) The Diagnosis and Recommendation Integrated System for monitoring nutrient status of rice in lowland areas in the vicinity of Satluj River in Punjab, *J. Indian Soc. Soil Sci*., 56: 198-204.
8. Jackson, M. L. (1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

9. Kar, R., Bose, P. C., Majumder, S. K. and Dutta, R. N. (2008) Physical characterization of mulberry (*Morus sp.*) growing soils in four states of Eastern India in relation to their organic carbon and available nutrient contents, *Indian J. Seric*., 47: 126-129.
10. Kar, R., Dutta, R. N. and Majumder, S. K. (1995) Characterization of humic acids isolated from soils under mulberry vegetation, *Curr. Sci*., 69: 67-68.
11. Kar, R., Ghosh, M. K., Majumder, S. K. and Nirmal Kumar, S. (2014) Induction of DRIS for foliar diagnosis of cationic micronutrients for mulberry (*Morus sp.*) growing under plains of West Bengal, *Nat. Sci*., 12 (4): 101-105.
12. Lindsay, W. L. and Norvell, W. A. (1978) Development of a DTPA soil test for zinc, iron, manganese and copper, *Soil Sci. Soc. America J*., 42: 421-428.
13. Mandal, B. and Roy, M. (1985) Soils of West Bengal and their management. *In Soils of India and their management.* Ed. Alexander T. M. The Fertilizer Association of India, New Delhi, India, pp. 430.
14. Payne, G. G., Rechcigl, J. E. and Stephenson, R. L. (1990) Development of diagnosis and recommendation integrated system norms for bahiagrass, *Agron. J.*, 82: 930-934.
15. Reis Junior, R. dos A. and Monnerat, P. H. (2003) DRIS norms validation for sugarcane crop, *Pesq. Agropec. Bras*., 38: 379-385.
16. Singh, M. V. and Behra, S. K. (2008) Micro- and secondary-nutrient deficiencies problems in Indian soils and their amelioration through balanced fertilization. *Extended Summaries: National Seminar on micro and secondary nutrients for balanced fertilization and food security.* Indian Institute of Soil Science, Bhopal, India, pp. 3-10.
17. Sumner, M. E. (1978) Interpretation of nutrient ratios in plant tissues, *Communications in Soil Science and Plant Analysis*, 9: 335-345
18. Synder, G. H., Sanchez, C. A. and Alrichs, J. S. (1989) DRIS evaluation of the nutrient status of Bahia and St. Augustine turfgrass, *Proc. Florida State Hort. Soc.*, 102: 133-137.
19. Walworth, J. L., Sumner, M. E., Issac, R. A. and Plank, C. O. (1986) Preliminary DRIS norms for alfalfa in the Southern United States and a comparison with the Midwest norms. *Agron. J.*, 78: 1046-1052.

5/1/2015