Induction of DRIS for foliar diagnosis of cationic micronutrients for mulberry (*Morus sp.*) growing under plains of West Bengal

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Abstract: The study aimed at the evaluation of the relationship between the Diagnosis and Recommendation Integrated System (DRIS) indices and foliar concentrations of cationic micronutrients, to ascertain optimum foliar concentration of the same for mulberry crop growing under plains of West Bengal. Foliar concentrations of cationic micronutrients from 78 mulberry (*Morus sp.*) commercial gardens were analyzed to calculate DRIS indices. Regression analysis was used to fit a model relating DRIS indices to foliar concentrations of the micronutrients under study. 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 plains of West Bengal are 16.56 mg kg^{-1} for Zn, 6.37 mg kg^{-1} for Cu, 163.84 mg kg^{-1} for Fe and 45.24 mg kg^{-1} for Mn, respectively. DRIS norms evaluated are useful to correct nutritional imbalances and to increase mulberry yield.

1. Introduction:

Analysis of plant-tissue is an established tool for correcting plant nutrient deficiencies and imbalances (Badlock and Schulte, 1996), optimizing crop production (Walworth *et al*., 1986), and for evaluating fertilizer requirements. Plant-tissue analysis can be interpreted successfully through the employment of DRIS norms (Hundal and Arora, 1996; Reis Junior and Monnerat, 2003; Hundal *et al*., 2008). Multiple two-way comparisons between the levels of various plant nutrients can be made through the DRIS system and these comparisons are, in turn, integrated into a series of nutrient indices (Walworth *et al*., 1986). This model is designed to determine when the nutrient contents of crops are excessive (positive indices), adequate (zero indices) or deficient (negative indices). 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).

Growth of mulberry depends upon genetic potential of the planting material, farm management practices and balanced plant nutrition. Unfortunately, the stress is now being only on major nutrients with no focus on micronutrients without which balanced nutrition is not possible. Cationic micronutrients like Zn, Cu, Fe and Mn are reported to be substantially deficient in Indian soils (Singh and Behra, 2008). Soils under different eco-geographic regions of Eastern India are mostly deficient in Zn ranging from 20% to 57%. In mulberry cultivation, studies on micronutrients are mostly restricted to Southern India (Bose *et al*., 1994 and 1995) and virtually no recommendation is available with respect to micronutrient in Eastern India. Micronutrient deficiency is increasingly becoming limiting factors in this part of country to further sustainable increase in mulberry production. Since soil organic matter is the natural source to replenish the available pool of micronutrient, widespread lack of organic matter in soils of this region (Kar *et al*., 2008) causes that micronutrient requirement by far exceeds the natural supply. Besides, continuous use of high analysis micronutrient-free fertilizers coupled with enhanced rate of micronutrient removal by mulberry due to intensive cropping with high yielding varieties have resulted in deficiency of micronutrient in the soils of mulberry garden.

In light of the above, the present study has been initiated to work out the strategy for management of cationic-micronutrients in mulberry gardens of plains of West Bengal through the employment DRIS norms. The relationship between foliar concentrations of the said micronutrients and DRIS indices can be used to make nutritional diagnosis. The fitted model between micronutrient concentration and respective DRIS index is suppose to exhibit negative and positive DRIS index and the same could be used to establish optimum foliar concentration, because the foliar

micronutrient concentration at null DRIS index do not limit crop yield (Reis Junior and Monnerat, 2003).

2. Materials and Methods:

Seventy eight commercial gardens of mulberry (*Morus sp.*) have been selected from commercial sericultural districts like Murshidabad and Malda 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 three ninety mulberry leaf samples were collected during five different seasons of a year from the corresponding mulberry gardens. The collected leaf samples were oven dried at 70^OC 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] x 1000/CV, when A / B ≥ a / b …….. (1)

or

f(A / B) = [1 - (A / B/(a / b)] x 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.

For assessment of optimum requirement of foliar micronutrient, regression analysis was used to fit a model that relates DRIS indices to floral micronutrient concentrations as independent variable (Reis Junior and Monnerat, 2003). The best fitting model was chosen among the linear and logarithm [y = a + b ln(x)] models. The optimum foliar concentration with DRIS has been established by the determination of the foliar micronutrient content that produces the null DRIS index.

3. Results and Discussion:

Micronutrients' availability in soil

Micronutrients' availability in the mulberry growing soils of plains 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 plains of West Bengal was mostly deficient in Zn (25.64%) followed by Fe (8.97%) and there was no deficiency of available Cu or Mn. Similar reports regarding deficiency of available zinc in soils of this zone are available both in agriculture as well as sericulture sectors (Singh and Bera, 2008; Samanta et al., 2002).

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

Micronutrient	Soil availability (mg kg^{-1})		Percent deficiency in soil
	Range	Mean	
Copper	0.57 - 6.08	2.46 ±0.176	-
Zinc	0.09 - 1.98	0.89 ±0.057	25.64
Iron	2.88 - 33.57	10.53 ±0.575	8.97
Manganese	3.58 - 32.12	18.66 ±0.701	-

Foliar composition of cationic micronutrients and their optimum requirement

Cu, Zn, Fe and Mn concentrations in mulberry leaves of different locations as presented in table-2 were used to work out 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). DRIS indices (I) as the quantitative evaluation of relative degree of imbalance

of micronutrient under the study was computed following the norms of Hundal and Arora (1996) and presented in the same table. The DRIS indices for individual micronutrient exhibits a range of negative or positive values and the same could be used to determine optimum foliar concentration, because the nutrient foliar concentration at null DRIS index possibly do not limit crop yield.

Table 2: Cationic micronutrients' contents in mulberry leaves corresponding to soil samples of plains of West

Micronutrient	Foliar content (mg kg^{-1})	
	Range	Mean
Copper	3.7 - 14.7	6.7 ±0.22
Zinc	10.6 - 46.5	19.2 ±0.74
Iron	73.4 - 305.5	144.2 ±6.33
Manganese	12.3 - 112.3	47.3 ±2.41

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

Micronutrient ratios					
Cu/Zn	Fe/Zn	Mn/Zn	Fe/Cu	Mn/Cu	Fe/Mn
0.37±0.03 (0.17-0.94)	7.92±0.64 (3.55-15.32)	2.68±0.36 (0.92-9.68)	22.31±1.70 (6.11-44.60)	7.37±0.78 (0.98-20.43)	3.56±0.35 (1.09-8.05)
DRIS functions (f)					
f (Cu/Zn)	f (Fe/Zn)	f (Mn/Zn)	f (Fe/Cu)	f (Mn/Cu)	f (Fe/Mn)
-31.96 to +40.46	-29.77 to +22.64	-28.29 to +38.68	-68.24 to +25.73	-121.96 to +33.02	-45.48 to +25.16
DRIS index (I)					
I$_{Cu}$		I$_{Zn}$	I$_{Fe}$		I$_{Mn}$
-11.09 to +76.88		-17.91 to +26.25	-20.77 to +24.51		-55.11 to +39.06

Further, regression analysis was used to fit a model that related DRIS indices to foliar micronutrient concentrations as independent variable (Reis Junior and Monnerat, 2003). The best fitting model was chosen among the linear and logarithm [y = a + b ln(x)] models. The optimum foliar concentration with DRIS was established by the determination of the foliar micronutrient content that produces the null DRIS index. A schematic presentation of the analysis is presented in figure I.

Statistical models were fitted between foliar micronutrient concentrations and respective DRIS indices as presented under figure-1 to work out the optimum requirement for individual micronutrient. The fitted models showed points where the DRIS indices were equal to zero and foliar micronutrient

concentrations at these points were not suppose to limit mulberry productivity. Foliar micronutrient concentration at this null DRIS index is considered as optimum requirement of the same (Reis Junior and Monnerat, 2003). The computed optimum foliar requirement of different cationic micronutrients under plains of West Bengal 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.

Table 4: Optimum requirement and toxic limit of cationic micronutrients for mulberry in terms of foliar content

Micronutrient	Regression equation	R^2	Optimum requirement (mg kg^{-1})	Toxic limit (mg kg^{-1})
Copper	y = 6.8963 x – 43.919	0.5626**	6.37	> 11.77
Zinc	y = 23.159 Ln(x) – 65.009	0.4461**	16.56	> 36.53
Iron	y = 0.1627 x – 26.656	0.6803**	163.84	> 293.27
Manganese	y = 27.489 Ln(x) – 104.79	0.7698**	45.24	>104.10

Relationship between Zn DRIS index and foliar Zn content

$y = 23.159 Ln(x) - 65.009$

$R^2 = 0.4461^{**}$

I_{Zn}

Foliar Zn (mg kg^{-1})

Relationship between Cu DRIS index and foliar Cu content

$y = 6.8963x - 43.919$

$R^2 = 0.5626^{**}$

I_{Cu}

Foliar Cu (mg kg^{-1})

Relationship between Fe DRIS index and foliar Fe content

$y = 0.1627x - 26.656$

$R^2 = 0.6803^{**}$

I_{Fe}

Foliar Fe (mg kg^{-1})

Relationship between Mn DRIS index and foliar Mn content

$y = 27.489 Ln(x) - 104.79$

$R^2 = 0.7698^{**}$

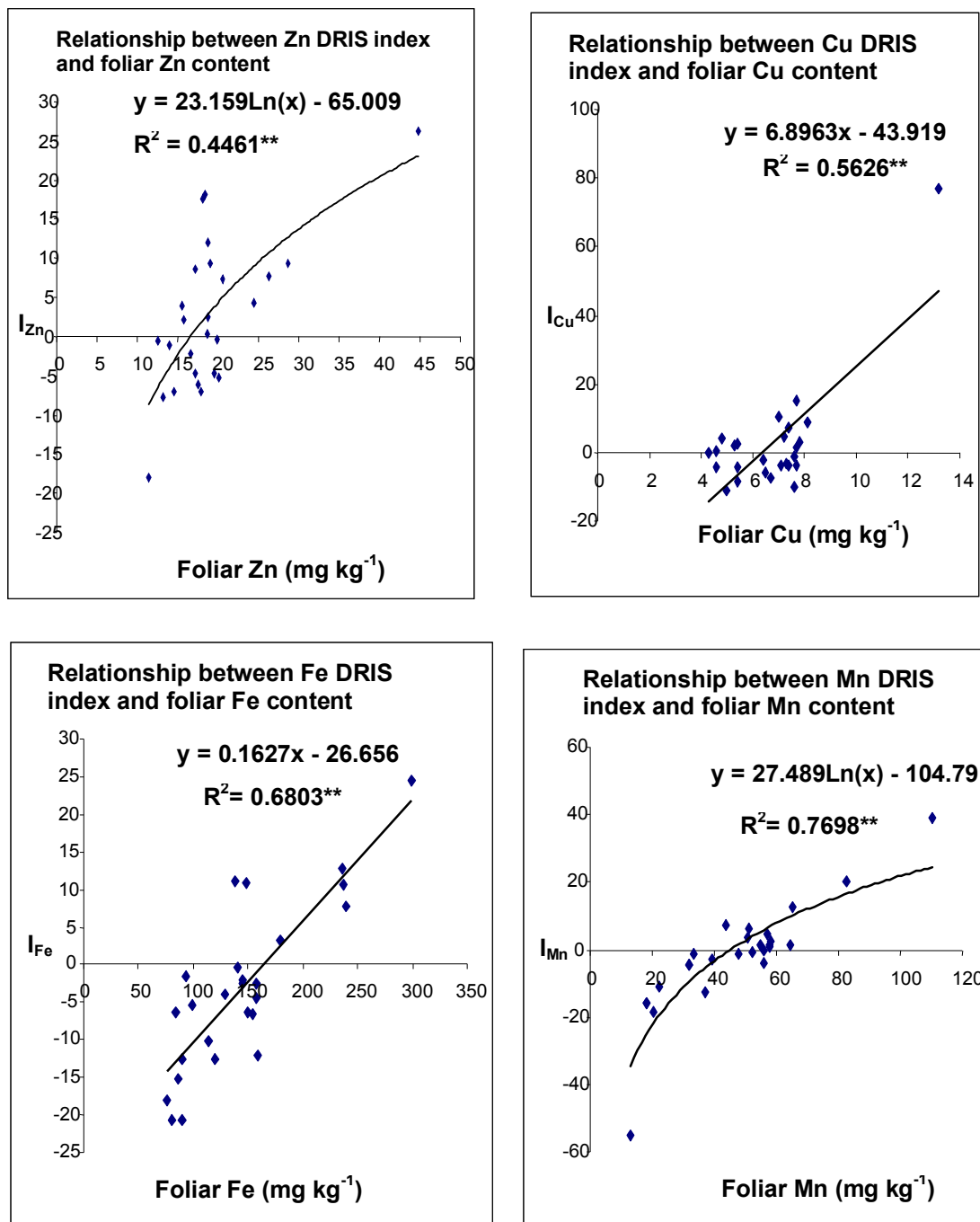I_{Mn}

Foliar Mn (mg kg^{-1})

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

It is conclusively evident from the investigation that DRIS norms developed from nutritional survey of mulberry crop could be employed to determine the optimum requirement of cationic micronutrients and 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 plains of West Bengal. Besides, DRIS derived sufficiency ranges for different cationic micronutrients can also be computed from foliar diagnostic norms, which in

conjunction with soil test database can avoid conducting of large number of field experiments on different soil types involving tremendous expenditure.

References

1. Baldock, J. O. and Schulte, E. E. (1996) Plant analysis with standardized scores combines DRIS and sufficiency range approaches for corn, *Agron. J.*, 88: 448-456.

2. 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.

3. 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.

4. Bose, P. C., Singhvi, N. R. and Dutta, R. K. (1994) Effect of micronutrients on yield and yield attributes of mulberry (*Morus alba* L.), *Indian J. Agron.*, 39: 97-99.

5. Bose, P. C., Sen, R. and Dutta, R. K. (1995) Effect of foliar application of micronutrients to mulberry on the rearing performances of silkworm, *Bombyx mori* L., *J. Seric.*, 3: 1-5.

6. Bhargava, B. S. (2002) Leaf analysis for nutrient diagnosis, recommendation and management in fruit crops, *J. Indian Soc. Soil Sci.*, 54: 353-373.

7. 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.

8. 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.

9. 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.

10. 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.

11. Jackson, M. L. (1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi.

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. Reis Junior, R. dos A. and Monnerat, P. H. (2003) DRIS norms validation for sugarcane crop, *Pesq. Agropec. Bras*., 38: 379-385.

14. Samanta, A., Chatterjee, P. K., Mete, P. K. and Biswapati Mandal (2002) Status of total and available iron and zinc in soils of West Bengal under continuous cultivation of mulberry, *J. Indian Soc. Soil Sci.*, 50: 35-42.

15. 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.

16. 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.

17. 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.

4/8/2014