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Comparison of CVA, DRIS, MDRIS and CND norms in rhizomes of turmeric crop in Coimbatore district of Tamil Nadu

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Abstract

The chemical characterization of turmeric growing soils of Coimbatore district indicated that they were free from salinity and the pH tended to be above neutral range. The excess $CaCO_3$ was also observed in these soils. About 78% of samples were strongly calcareous (> 5 % free $CaCO_3$) while 22% were weakly calcareous (< 5 % free $CaCO_3$). The alkaline $KMnO_4$ was in the lower range whereas P and K status were in medium to very high status. The S was deficient in 19 per cent soils. Zinc, Boron and Iron deficiencies are seen to an extent of 62, 51and 30%, respectively. A significant negative correlation was observed between Zn, B and Fe with free $CaCO_3$ content of soils. Using the new norms of DRIS / MDRIS for rhizomes, the extent of deficiency of none of the micronutrient (Zn, B and Fe) did match with the values assessed with the soil analysis. The study indicated that 17 per cent of turmeric growing areas was severely limited by mineral nutrition. About 23 per cent was identified as having possible imbalances. Based on the order of requirement, predominance of Zn deficiency was well indicated by CND than DRIS.

Key words: CVA, DRIS, MDRIS, CND, rhizome, turmeric.

Introduction

Turmeric is one of the important commercial crops of Coimbatore district with duration of 9 to 10 months and is cultivated under well irrigation system. Tamil Nadu accounts for 12.2 per cent of the total area and 17.2 per cent of production of turmeric (Kathirvel and Maniam, 1999). India is world's largest turmeric producer and may gain importance in export of oleoresin and curcumin having high medicinal value (Catalan *et al.*, 1989; Rama Rao and Rao, 1994 and Tamil Selvam *et al.*, 1999). Introduction of high yielding varieties and use of high doses of fertilizers besides its calcareous nature of soils micronutrient deficiencies are occurring and affecting the growth and yield of turmeric crop. There were frequent reports of iron chlorosis and zinc deficiency in the turmeric crop (Madhavi *et al.*, 1995). The soil nutrient status is often reported to play a crucial role in determining not only the yield but also the quality. As the large area cultivation under this crop is highly region specific, research information on soil constraints especially the impact of soil micronutrient deficiencies limiting turmeric production in Coimbatore district has been investigated.

Materials and methods

About 500 soil and rhizome samples were obtained from commercial turmeric growing fields of Coimbatore district in Tamil Nadu during July-September, 2000. The soil samples collected from the survey area were analysed for pH (1:2 soil: water), EC, organic carbon, free $CaCO_3$, available N, P and K, Ca, Mg and Na, available S, hot water soluble B, DTPA extractable Zn, Cu, Fe and Mn by adopting standard procedures (Jackson, 1973). The limit proposed by Lindsay and Norvell (1978) was adopted to classify the soil with respect to macro and micronutrient status. Correlations between micronutrients and soil characteristics were worked out following the method suggested by Panse and Sukhatme (1978). The dried sample was ground to pass a 20 mesh screen in a stainless steel Wiley mill and analyzed for total N by micro-Kjeldahl. A portion of the ground sample was digested in nitric and perchloric acids. Total P was determined by molybdovanadophosphate colorimetric procedure and K and Na by the flame photometry. The Ca and Mg were determined by Versanate titration method, sulphur by turbidimetry, B by Azomethine method, micronutrients by atomic absorption spectrophotometry. DRIS / MDRIS (Diagnosis Recommendation Integrated System (DRIS) of Beaufils, (1973) / Modified Diagnosis Recommendation Integrated System (MDRIS) of Beaufils, (1973) provides a means of ordering nutrient ratios or products into meaningful expressions called DRIS / MDRIS indices. Essentially, a nutrient index is a mean of the deviations of the ratios constraining a given nutrient from their respective optimum or norm values. The first step in implementing DRIS / MDRIS is the establishment of these standard values or norms. This was done using a survey data of turmeric in which yield data was collected from cropping enterprise and nutrients concentration from the plant analysis data in order to build up a data base representative of the locations and crops. Using yield and plant tissue nutrient concentration from the survey data DRIS norms and coefficients of variations (CV) were derived for turmeric according to the procedure by Walworth and Sumner (1987). The statistical Critical Value Approach (CVA) of Cate and Nelson (1971) was used to derive the cut off for the high yielding and low yielding populations. Mean values for each nutrient expression together with their associated CVs and variances were then calculated for the two populations. The mean values (high yielding population) of 12 nutrient expressions were ultimately chosen as diagnostic norms for turmeric crop. The same set of data was also used for

developing nutrient norms and indices of Compositional Nutritional Diagnosis (CND) approach of Parent and Dafir (1992).

Results and discussion

Characteristics of turmeric growing soils: The soils are neutral to slightly alkaline in reaction and the pH varied from 7.5 to 8.80 with a mean value of 8.26 (Table 1). They were non-saline, the EC varied from 0.11 to 0.69 dSm^{-1} with a mean value of 0.28 dSm^{-1}. The turmeric growing soils are though free from salinity, the pH tends to be above neutral range and few fields showed pH values exceeding 8.0. In general, 78 per cent of the soil samples were strongly calcareous (> 5 % free $CaCO_3$), while 22 per cent were weakly calcareous (< 5 % free $CaCO_3$). The presence of excess $CaCO_3$ in the soils might have resulted in increased pH and strongly influences the retention, fixation and adsorption of plant nutrients. The organic carbon status, in general, was medium to high and ranged from 0.25 to 1.57 per cent with a mean value of 1.29 per cent. However, majority of the turmeric growing farmers are progressive in nature, following INM practices and take extra care in the addition of optimal level of fertilizers. Similar results were reported by Rajarao (1976) and Madhavi *et al.* (1995). The $KMnO_4$ - N status ranged from 170 to 290 kg ha^{-1} with a mean value of 223 kg ha^{-1}. In spite of the high organic carbon content of turmeric growing soils, the alkaline $KMnO_4$ - N is in the lower range in 96 per cent of the soils. However, P and K status are in medium to very high status. The content of other nutrients in the soils are given in Table 1.

Table 1. Characteristics of turmeric growing soils

Properties	Range	Mean	Percent deficiency	SD	CV
pH	7.5 0 – 8.80	8.26	-	0.34	4.1
EC (dSm^{-1})	0.11 – 0.69	0.28	-	0.13	45.9
Org. C (%)	0.25 – 1.57	1.29	4	0.30	23.0
Free $CaCO_3$ (%)	2.40 – 13.6	7.35	-	3.66	49.8
$KMnO_4$ -. N (kg ha^{-1})	170 – 290	223	96	342	15.3
Olsen - P (kg ha^{-1})	16.9 – 93.9	60.7	-	17.2	28.3
NH_4OAc -. K (kg ha^{-1})	264 – 770	487	-	151	31.0
NH_4OAc -. Ca (mg kg^{-1})	318 – 1189	714	-	274	38.4
NH_4OAc -. Mg(mg kg^{-1})	27.6 – 168.9	93.0	-	38.0	40.9
$CaCl_2$ -. S (mg kg^{-1})	3.20 – 173.5	48.6	19	40.5	83.4
Av. B (mg kg^{-1})	0.11 – 0.89	0.46	51	0.26	55.4
DTPA – Zn (mg kg^{-1})	0.20 – 4.00	1.07	62	0.84	78.5
DTPA – Cu (mg kg^{-1})	0.80 – 6.00	3.15	-	1.48	47.1
DTPA – Fe (mg kg^{-1})	1.80 – 26.6	6.45	30	4.65	72.0
DTPA – Mn (mg kg^{-1})	7.70 – 19.8	14.4	-	2.85	19.9

Table 2. Mineral composition of rhizomes of turmeric

Nutrients	Range	Mean	SD	CV
N (%)	0.87 – 2.94	1.77	0.54	30.4
P (%)	0.19 – 1.45	0.54	0.33	59.4
K (%)	1.67 – 10.2	4.45	1.83	40.5
Ca (%)	0.10 – 1.58	0.31	0.17	55.5
Mg (%)	0.24 – 2.17	0.75	0.38	49.6
Na (%)	0.05 – 0.52	0.16	0.10	58.4
S (%)	0.06 – 0.54	0.17	0.10	58.0
B (mg kg^{-1})	4.90 – 21.6	11.4	3.98	36.2
Zn (mg kg^{-1})	32.0 – 115	63.8	21.4	32.7
Cu (mg kg^{-1})	13.0 – 70.0	25.1	9.48	38.6
Fe (mg kg^{-1})	179 – 1646	695	407	58.1
Mn (mg kg^{-1})	14.0 – 185	36.4	86.4	53.3

Table 3. DRIS / MDRIS foliar diagnostic reference nutrient ratios in turmeric rhizomes of Coimbatore district

Nutrient ratios	High Yielding Population			Low Yielding Population			Variance ratio
	Mean	CV	SD	Mean	CV	SD	(LYP/HYP)
N/P	3.76	53.7	2.02	4.02	58.5	2.35	1.36
N/K	2.76	30.1	0.83	2.62	58.8	1.54	3.43
N/Ca	5.56	53.4	2.97	7.85	38.7	3.03	1.05
Mg/N	0.763	44.0	0.336	0.602	56.1	0.338	1.01
N/S	8.56	57.1	4.89	14.2	50.7	7.18	2.16
N/B	1650.00	56.2	928.0	1683.0	56.9	957.0	1.06
Cu/N	0.0017	44.3	0.0008	0.0015	55.6	0.0008	1.21
K/P	9.67	49.1	4.75	9.61	51.7	4.97	1.10
P/Ca	1.97	80.7	1.59	2.51	57.9	1.45	0.84
Mg/P	2.49	45.7	1.14	2.15	51.6	1.108	0.95
P/S	2.81	63.9	1.79	4.26	56.7	2.42	1.82
P/B	547.0	76.5	419.0	527.0	71.8	379.0	0.82
P/Zn	96.8	67.4	65.2	98.7	61.1	60.3	0.86
P/Cu	220.0	48.0	106.0	238.0	54.8	130.0	1.52
P/Fe	10.5	79.9	8.39	8.66	63.0	5.46	0.42
K/Ca	14.8	49.1	7.27	20.0	40.4	8.08	1.24
Mg/K	0.283	40.9	0.116	0.239	55.6	0.133	1.31
K/S	22.7	48.9	11.1	35.1	43.8	15.4	1.93
Zn/K	0.0016	51.7	0.0008	0.0015	54.2	0.0008	0.93
Cu/K	0.0006	41.7	0.0003	0.0006	53.3	0.0003	1.44
K/Mn	592.0	64.4	381.0	644.0	69.4	446.0	1.37
Mg/Ca	3.70	46.3	1.71	4.34	58.0	2.52	2.16
S/Ca	0.674	31.6	0.213	0.618	56.5	0.349	2.68
B/Ca	0.004	67.9	0.0027	0.0053	55.0	0.0029	1.14
Zn/Ca	0.020	35.1	0.007	0.026	60.5	0.0159	5.18
Cu/Ca	0.0082	42.4	0.0035	0.011	55.4	0.006	2.98
Fe/Ca	0.238	62.1	0.148	0.359	29.3	0.105	0.51
Mn/Ca	0.032	71.6	0.0227	0.039	54.5	0.0212	0.87
Mg/S	5.76	49.3	2.83	7.76	42.5	3.29	1.35
B/Mg	0.0012	53.8	0.0006	0.0013	51.8	0.0007	1.14
Zn/Mg	0.0061	44.1	0.0027	0.0064	58.7	0.0038	1.98
Cu/Mg	0.0024	31.5	0.0008	0.0027	51.8	0.0014	3.34
Fe/Mg	0.070	59.1	0.042	0.087	43.6	0.038	0.82
Mn/Mg	0.0089	55.0	0.0049	0.0096	49.6	0.0048	0.94
Na/S	0.864	33.6	0.290	1.11	38.0	0.424	2.13
Na/Zn	0.0368	33.6	0.0124	0.045	55.2	0.0251	4.11
Cu/Na	0.0148	29.5	0.0044	0.018	57.9	0.0105	5.75
Fe/Na	0.434	55.9	0.243	0.598	39.9	0.238	0.97
B/S	0.0062	56.2	0.0035	0.0094	51.8	0.0049	1.94
Zn/S	0.0309	36.1	0.0111	0.0473	54.4	0.0258	5.36
Cu/S	0.0124	33.5	0.0042	0.019	53.9	0.0104	6.24
Mn/S	0.047	70.6	0.0331	0.071	45.8	0.0324	0.96
Zn/B	5.91	41.3	2.44	5.60	53.2	2.98	1.48
Cu/B	2.46	46.1	1.13	2.25	51.7	1.17	1.06
B/Fe	0.0231	88.3	0.0204	0.0204	69.5	0.0142	0.48
B/Mn	0.190	104.4	0.198	0.191	92.2	0.176	0.79
Cu/Zn	0.419	23.0	0.0963	0.423	58.1	0.246	6.50
Fe/Zn	11.9	45.9	5.48	14.1	38.0	5.34	0.95
Mn/Zn	1.56	54.7	0.85	1.53	51.4	0.788	0.86
Fe/Cu	29.6	50.5	14.9	33.8	47.8	16.1	1.17
Cu/Mn	0.344	61.8	0.213	0.369	76.5	0.283	1.76
Fe/Mn	9.50	62.3	5.91	12.3	104.9	13.0	4.79

Nutrient status of turmeric rhizomes: The N content of the rhizomes ranged from 0.87 to 2.94 per cent with the mean values of 1.77 per cent (Table 2). The P content ranged from 0.19 to 1.45 per cent with the mean value of 0.54 per cent. The K content ranged from 1.67 to 10.2 per cent with the mean value of 4.45 %. The values of Ca content of the rhizomes was 0.10 to 1.58 % with the mean value of 0.31%. It was

Table 4. New foliar diagnostic reference norms for nutrient concentration in rhizomes of turmeric crop

Nutrients	DRIS / MDRIS					CND				
	Critical value	CV	Deficiency	Optimum	Excess	Critical value	CV	Deficiency	Optimum	Excess
N (%)	1.73	30.6	< 1.02	1.03 – 2.42	> 2.43	1.68	44.4	< 1.06	1.07 – 2.66	> 2.67
P (%)	0.56	50.7	< 0.18	0.19 – 0.93	> 0.94	0.51	56.2	< 0.29	0.30 – 0.87	> 0.88
K (%)	3.67	28.0	< 2.30	2.31 – 5.02	> 5.03	3.60	46.9	< 2.22	2.23 – 5.82	> 5.83
Ca (%)	0.33	50.5	< 0.11	0.12 – 0.54	> 0.55	0.30	42.5	< 0.19	0.20 – 0.46	> 0.47
Mg (%)	0.76	45.2	< 0.31	0.32 – 1.21	> 1.22	0.70	54.1	< 0.41	0.42 – 1.20	> 1.21
Na (%)	0.18	70.1	< 0.01	0.02 – 0.33	> 0.34	0.15	77.6	< 0.07	0.08 – 0.28	> 0.29
S (%)	0.16	46.9	< 0.06	0.07 – 0.26	> 0.27	0.15	48.7	< 0.09	0.10 – 0.25	> 0.25
B (mg kg^{-1})	11.7	32.7	< 6.6	6.7 – 16.7	> 16.8	11.0	45.7	< 7.20	7.21 – 17.6	> 17.7
Zn (mg kg^{-1})	72.6	28.3	< 45.2	45.3 – 99.8	> 99.9	71.0	30.9	< 50.3	50.4 – 99	> 100
Cu (mg kg^{-1})	23.4	30.1	< 14.0	14.1 – 32.6	> 32.7	23.0	31.7	< 15.7	15.8 – 32.6	> 32.7
Fe (mg kg^{-1})	539	49.5	< 184	195 – 893	> 894	480	92.1	< 216	217 - 1068	> 1069
Mn (mg kg^{-1})	105	47.6	< 38.7	38.8 - 171	> 172	91.0	94.3	< 40.6	40.7 – 204	> 205

0.24 to 2.17 % with the mean value of 0.75 % in the case of Mg. Na ranged from 0.05 to 0.52 % with the mean value of 0.16 %, whereas the S content ranged from 0.06 to 0.54 % with the mean value of 0.17 %. Boron content ranged from 4.9 to 21.6 mg kg^{-1} with the mean value of 11.4 mg kg^{-1}. The Zn content in the rhizomes ranged from 32 to 115 mg kg^{-1} with the mean value of 63.8 mg kg^{-1}. The Cu content of the rhizomes ranged from 13 to 70 mg kg^{-1} with the mean value of 25.1 mg kg^{-1}. In the rhizomes, Fe ranged from 179 to 1646 mg kg^{-1} with the mean value of 695 mg kg^{-1}. The Mn ranged from 14 to 185 mg kg^{-1} with the mean value of 86.4 mg kg^{-1}.

Optimum nutrient concentration: The various DRIS nutrient ratio norms are given in Table 3. The DRIS optimum range values of N, P, K, Ca, Mg, Na, and S content, based on the sampling of the rhizomes of turmeric in Coimbatore district were 1.02 – 2.43, 0.18 – 0.94, 2.30 – 5.03, 0.11 – 0.55, 0.31 – 1.22, 0.01 – 0.34 and 0.06 – 0.27 % (Table 4) with RPZI value of 2.97, 1.14, 7.41, 0.54, 1.04, 0.31 and 0.47 %, respectively, whereas in the case of B, Zn, Cu, Fe and Mn, it ranged from 6.6 to 16.8, 45.2 to 99.9, 14.0 to 32.7, 184.1 to 893.6 and 38.7 to 172.1 Mg kg^{-1} with reference to critical concentration of 25.0, 77.2, 30.4, 1029.0 and 94.8 Mg kg^{-1}, respectively. The N, P, K, Ca, Mg, Na, and S optimum range values of 1.06 – 2.67, 0.29 – 0.88, 2.22 – 5.83, 0.19 – 0.47, 0.41 – 1.21, 0.07 – 0.29 and 0.09 – 0.25 % with critical values of 1.68, 0.51, 3.60, 0.30, 0.70, 0.15 and 0.15 %, respectively and B, Zn, Cu, Fe and Mn content ranged from 7.2 to 17.7, 50.3 to 100.2, 15.7 to 32.7, 215.6 to 1068.5 and 40.6 to 205.2 Mg kg^{-1} with RPZI value of 11, 71, 23, 480 and 91 Mg kg^{-1}, respectively were derived using the CND norms. In this area 6, 0, 6, 2, 4, 0, 0, 10, 14, 6, 4 and 14 % based on DRIS and 6, 18, 6, 22, 16, 10, 14, 14, 22, 12, 4 and 16 % deficiency of N, P, K, Ca, Mg, Na, S, B, Zn, Cu, Fe and Mn content, respectively in the case of CND were recorded (Table 5).

Nutritional Imbalance Index: The NII in turmeric growing areas (17 %) were severely limited by mineral nutrition (Table 6). About 23 per cent were identified as having possible imbalances based on the NII mean values of 6284 derived from high yielding population.

Table 5. Classification and evaluation of nutrient status using new norms in rhizomes of turmeric crop (%)

Nutrient	DRIS			CND		
	DEF	OPT	EXC	DEF	OPT	EXC
N	6	80	14	6	88	6
P	-	90	10	18	68	14
K	6	68	26	6	72	22
Ca	2	92	6	22	66	12
Mg	4	82	14	16	70	14
Na	-	96	4	10	80	10
S	-	88	12	14	72	14
B	10	76	14	14	74	12
Zn	14	80	6	22	72	6
Cu	6	76	18	12	70	18
Fe	4	70	26	4	80	16
Mn	14	82	4	16	84	-

Table 6. Evaluation of nutrient indices using DRIS, MDRIS and CND approaches in the rhizomes of turmeric crop

Approach	N	P	K	Ca	Mg	Na	S	B	Zn	Cu	Fe	Mn	Yield	NII
DRIS	-156	-31	28	-78	-47	51	40	-345	-69	53	431	123		1452
MDRIS	50	7	37	-1	8	7	8	-26	-5	5	38	10	-137	338
CND	-0.05	-0.02	0.36	-0.20	-0.05	0.05	0.16	-0.16	-0.65	0.10	0.48	-0.16		

Table 7. Order of yield limiting nutrients based on the indices of DRIS, MDRIS and CND approaches in the rhizomes of turmeric crop

Approach	Order of limitation → decreasing trend of limitation →
DRIS	*B* > *N* > *Ca* > *Zn* > *Mg* > *P* > K > S > Na > Cu > Mn > Fe
MDRIS	*Y** > *B* > *Zn* > *Ca* > Cu > P > Na > S > Mg > Mn > K > Fe > N
CND	*Zn* > *Ca* > *B* > *Mn* > *N* > *Mg* > *P* > Na > Cu > S > K > Fe

The nutrient in italics represents the negative indices of the concerned nutrient

Identification of yield limiting nutrients by DRIS indices: The study indicated in Coimbatore, out of 500 fields surveyed, 340 fields were low yielding having yield less than 32.7 t ha^{-1} (Table 6). The order in which the nutrients are limiting yield indicated that most often more than one nutrient is limiting the yield. The order of limitation of the nutrients with special reference to severe limitation of Zn, where compared to other norms CND highlights Zn deficiency to higher extent than DRIS or MDRIS (Table 7). The accuracy of the CND involving multivariate analysis for reliable projection of the data has been indicated by various

authors in other crops (Parent and Dafir, 1992; Parent *et al.*, 1993; Parent *et al.*, 1994 and Raghupathi and Bhargava, 1999).

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