



Status of Micronutrients in Mixed Red and Black Soils of Rewa District of Madhya Pradesh, India

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Delineation work was undertaken to evaluate the status of micronutrients in mixed red and black soils of Rewa district (Madhya Pradesh). The district is spread between latitude-24°21'59.9" N to 24°48'40.9" N and longitude-81°09'21.8" E to 82°02'02.2" E. The mean value of pH, electrical conductivity, organic carbon and CaCO₃ in soil were 7.45, 0.21 dSm⁻¹, 5.03 g kg⁻¹ and 2.83 g kg⁻¹, respectively. The average Zn, Cu, Fe, Mn and B contents were observed as 0.69, 1.17, 20.87, 14.41 and 1.34 mg kg⁻¹, respectively. The available Zn, Cu, Fe and Mn showed negative correlation with soil pH, whereas available boron content exhibited positive correlation. Zinc and boron showed positive and significant correlation with organic carbon. Similarly, Zn, Mn and B were found negatively and significant correlation with CaCO₃. The results of the study indicated that zinc (Zn : 55.9 %) and iron (Fe: 2.0 %) deficiency are the major disorders in mixed red and black soils of Rewa district of Madhya Pradesh, India.

Key Words: Micronutrient status, GPS technique, Mix red and black soils, Rewa district of Madhya Pradesh.

INTRODUCTION

The word micronutrient represents some essential plant nutrients that are required in very small quantities for the growth, development and reproduction of plant as major nutrients. Green revolution has significantly increased the food crop production in India, accomplished through growing of high yielding varieties; use of high analysis NPK fertilizers, increase in irrigated areas and increase in cropping intensity catalyzed the depletion of the finite reserve micronutrients in soil. Indiscriminate use of high analysis chemical fertilizers results in the deficiency of secondary and micronutrients in soils¹. Variability in micronutrient contents of the soils is a mirror of the diversity in parent materials from which these have originated². Information about the extent of micronutrient deficient area is necessary for the scientists, administrators, farmers and fertilizer manufacturers to determine the kind and quantity of fertilizer required for the particular region. There is a need to blend the traditional knowledge with frontier technologies. Geo-positioning system is the tool of such frontier technology which, would help in generation of agricultural management system and formulating plans for sustainable agricultural development. The geo referenced sampling sites can be revisited with the help of GPS, which helps in monitoring the changes in the status of micronutrients over a period of time, which otherwise is not possible by traditional methods of sampling. This study was conducted to

assess the status of micronutrient contents in mix red and black soils of rice-wheat growing region of Rewa district, Madhya Pradesh, India.

EXPERIMENTAL

The study area is located in Rewa district of Madhya Pradesh (latitude-24°21'59.9"N to 24°48'40.9"N and longitudes-81°09'21.8"E to 82°02'02.2"E). Climate of this region is semi arid and sub tropical. Geo referenced two hundred and four surface soil samples were collected after harvest of crop during the month of November 2010. Locations of sampling sites were decided using geo-positioning system. These details of soil sample of Rewa district were given in Table-1.

Basic soil parameters were estimated using standard laboratory methods. Soil available Zn, Fe, Mn and Cu were extracted with DTPA as outlined by Lindsay and Norvell³ and estimated by using atomic absorption spectrophotometer, whereas available B (hot water soluble B) content in soil was determined by azomethine-H method⁴ and estimated by using spectrophotometer. Further, data were processed statistically to obtain the proposed objectives. The limits of micronutrients (mg kg⁻¹) were used for various categories (low, medium and high) as suggested by Singh *et al.*¹ are given as:

Micronutrients	Low	Medium	High
Zn	<0.6	0.6-1.2	>1.2
Cu	<0.2	0.2-0.4	> 0.4

TABLE-1
LOCATION OF SOIL SAMPLES COLLECTED FROM DISTRICT REWA

Tehsils	N.S.	Longitude		Latitude	
		From	To	From	To
Rewa	43	24°28'26.6" N	24°48'37.5" N	81°10'50.4" E	81°47'10.9" E
Gudh	25	24°21'59.9" N	24°28'27.3" N	81°13'31.5" E	81°18'35.3" E
Sirmor	45	24°37'17.5" N	24°47'19.5" N	81°09'21.8" E	81°15'42.4" E
Raipur Karchuliyan	17	24°34'32.6" N	24°39'19.6" N	81°26'02.2" E	81°33'08.4" E
Teonther	25	24°39'36.0" N	24°48'18.2" N	81°33'18.7" E	81°46'10.5" E
Mouganj	35	24°40'22.8" N	24°48'40.9" N	81°40'59.9" E	81°55'12.0" E
Hanumana	14	24°41'02.3" N	24°44'03.2" N	81°55'34.7" E	82°02'02.2" E
District Rewa	204	24°21'59.9" N	24°48'40.9" N	81°09'21.8" E	82°02'02.2" E

TABLE-2
BASIC PROPERTIES OF SOILS

Tehsils	pH		EC (dSm ⁻¹)		CaCO ₃ (g kg ⁻¹)		OC (g kg ⁻¹)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Rewa	6.30-8.10	7.66	0.11-0.79	0.23	1.00-12.00	3.66	3.30-9.60	5.36
Gudh	6.80-8.00	7.59	0.15-0.45	0.20	1.00-7.00	3.24	4.20-8.00	5.71
Sirmor	5.90-8.00	7.46	0.10-0.88	0.23	1.00-13.50	3.40	2.10-10.30	4.57
Raipur Karchuliyan	6.50-8.00	7.66	0.10-0.42	0.18	1.00-7.50	2.92	3.60-7.70	5.00
Teonther	5.50-8.00	7.39	0.10-0.87	0.23	1.00-7.50	2.17	2.10-7.50	4.46
Mouganj	5.60-7.90	7.08	0.10-0.51	0.21	0.50-4.50	1.85	3.10-8.60	4.76
Hanumana	6.20-7.70	6.93	0.10-0.41	0.17	1.00-3.50	2.09	3.40-11.00	6.36
District Rewa	5.50-8.10	7.45	0.10-0.88	0.21	0.50-13.50	2.83	2.10-11.00	5.03

TABLE-3
DISTRIBUTION OF AVAILABLE MICRONUTRIENTS CONTENT (mg kg⁻¹)
AND ITS PERCENT SAMPLE DEFICIENCY OF REWA DISTRICT

Tehsils	Zn			Cu			Fe			Mn		
	Range	Mean	PSD	Range	Mean	PSD	Range	Mean	PSD	Range	Mean	PSD
Rewa	0.13-1.43	0.46	72.09	0.34-4.15	1.53	0.0	4.64-98.30	25.96	0.0	2.05-87.30	16.63	0.0
Gudh	0.13-0.99	0.34	88.00	0.43-4.22	1.38	0.0	4.69-101.30	18.46	0.0	2.26-88.30	21.84	0.0
Sirmor	0.11-2.77	0.46	80.00	0.23-4.33	0.84	0.0	4.34-106.20	29.02	4.40	2.27-127.30	17.30	0.0
Raipur Karchuliyan	0.53-1.88	1.11	5.88	0.35-1.28	0.67	0.0	2.43-99.30	16.06	11.80	4.34-11.46	7.41	0.0
Teonther	0.11-1.95	0.80	36.00	0.44-4.88	1.44	0.0	4.88-112.30	17.05	0.0	3.98-56.30	10.34	0.0
Mouganj	0.23-2.77	1.13	25.71	0.34-4.77	1.25	0.0	4.61-115.30	16.60	0.0	2.76-119.00	12.78	0.0
Hanumana	0.15-3.18	1.07	42.86	0.44-4.11	1.15	0.0	6.12-74.20	25.71	0.0	2.23-102.30	18.82	0.0
District Rewa	0.11-3.18	0.69	55.88	0.23-4.88	1.17	0.0	2.43-115.30	20.87	2.00	2.05-127.30	14.41	0.0

Micronutrients	Low	Medium	High
Fe	< 4.5	4.5-9.0	>9.0
Mn	<2.0	2.0-4.0	>4.0
B	<0.1	0.1-0.60	>0.60
N.I.	<1.67	1.67-2.33	>2.33

RESULTS AND DISCUSSION

Basic properties of soils: The results of present study on soil properties are presented in Table-2. It is indicated that the soil pH varied from 5.5 to 8.1 with mean value of 7.45 in Rewa district. Thus, the soil samples of Rewa district were found to be slightly acidic. Electrical conductivity ranged from 0.10 to 0.88 with mean value of 0.21 dSm⁻¹ hence, soils of Rewa districts were found to be low in soluble salts. Organic carbon content in soils was found to vary from 2.10 to 13.50 g kg⁻¹ with mean value 5.03 g ka⁻¹ in Rewa district. CaCO₃ content varied from 0.50 to 13.50 g kg⁻¹ with mean value 2.83 g kg⁻¹ in Rewa district. It is indicating that the mixed red and black soil of Rewa districts were medium in organic carbon content and non calcareous in respect of CaCO₃ content.

Status of micronutrients in mix red and black soils

DTPA-extractable zinc: The data presented in Table-3 indicate that the available Zn content in soils was found to vary from 0.13 to 1.43 mg kg⁻¹ with a mean value of 0.46 mg kg⁻¹ in Rewa tehsil, 0.13 to 0.99 mg kg⁻¹ with a mean value of 0.34 mg kg⁻¹ in Gudh tehsil, 0.11 to 2.77 mg kg⁻¹ with a mean value of 0.46 mg kg⁻¹ in Sirmor tehsil, 0.53 to 1.88 mg kg⁻¹ with a mean value of 1.11 mg kg⁻¹ in Raipur Karchliyan tehsil, 0.11 to 1.95 mg kg⁻¹ with a mean value of 0.80 mg kg⁻¹. Teonther tehsil, 0.23 to 2.77 mg kg⁻¹ with a mean value of 1.13 mg kg⁻¹ in Mouganj tehsil, 0.15 to 3.18 mg kg⁻¹ with a mean value of 1.07 mg kg⁻¹ in Hanumana tehsil. For the entire Rewa, district, available zinc content in soils varied from 0.11 to 3.18 mg kg⁻¹ with a mean value of 0.69 mg kg⁻¹ of soil. Considering 0.6 mg kg⁻¹ DTPA extractable Zn as the critical limit, below which response of crops to the application of Zn may be expected 72.09, 88.00, 80.00, 5.88, 36.00, 25.71 and 42.86 percent samples were found deficient in Rewa, Gudh, Sirmor, Raipur Karchuliyan, Teonther, Mouganj and Hanumana tehsil, respectively. For the Rewa district as a whole 55.88 % samples were tested low in available zinc.

DTPA extractable copper: The available copper content in soils was found to vary from 0.34 to 4.15 mg kg⁻¹ with a mean value of 1.53 mg kg⁻¹ in Rewa tehsil, 0.43 to 4.22 mg kg⁻¹ with a mean value of 1.38 mg kg⁻¹ in Gudh tehsil, 0.23 to 4.33 mg kg⁻¹ with a mean value of 0.84 mg kg⁻¹ in Sirmor tehsil, 0.35 to 1.28 mg kg⁻¹ with a mean value of 0.67 mg kg⁻¹ in Raipur Karchliyan tehsil, 0.44 to 4.88 mg kg⁻¹ with a mean value of 1.44 mg kg⁻¹ in Teonther tehsil, 0.34 to 4.77 mg kg⁻¹ with a mean value of 1.25 mg kg⁻¹ in Mouganj tehsil, 0.44 to 4.11 mg kg⁻¹ with a mean value of 1.15 mg kg⁻¹ in Hanumana tehsil. For the entire Rewa district, available Cu content in soils varied from 0.23 to 4.88 mg kg⁻¹ with a mean value of 1.17 mg kg⁻¹ of soil. None of the samples were tested low in Cu (Table-3).

DTPA extractable iron: The available Fe content in soils (Table-3) was found to vary from 4.64 to 98.30 mg kg⁻¹ with a mean value of 25.96 mg kg⁻¹ in Rewa tehsil, 4.69 to 101.30 mg kg⁻¹ with a mean value of 18.46 mg kg⁻¹ in Gudh tehsil, 4.34 to 106.20 mg kg⁻¹ with a mean value of 29.02 mg kg⁻¹ in Sirmor tehsil, 2.43 to 99.30 mg kg⁻¹ with a mean value of 16.06 mg kg⁻¹ in Raipur Karchliyan tehsil, 4.88 to 112.30 mg kg⁻¹ with a mean value of 17.05 mg kg⁻¹ in Teonther tehsil, 4.61 to 115.30 mg kg⁻¹ with a mean value of 16.60 mg kg⁻¹ in Mouganj tehsil, 6.12 to 74.40 mg kg⁻¹ with a mean value of 25.71 mg kg⁻¹ in Hanumana tehsil. For the entire Rewa district, available Fe content in soils varied from 2.43 to 115.30 mg kg⁻¹ with a mean value of 50.1 mg kg⁻¹ of soil. Only 2.0 % samples were tested low in iron.

DTPA extractable manganese: As revealed by the data given in the Table-3 the available Mn content in soils was found to vary from 2.05 to 87.30 mg kg⁻¹ with a mean value of 16.63 mg kg⁻¹ in Rewa tehsil, 2.26 to 88.30 mg kg⁻¹ with a mean value of 21.84 mg kg⁻¹ in Gudh tehsil, 2.27 to 127.30 mg kg⁻¹ with a mean value of 17.30 mg kg⁻¹ in Sirmor tehsil, 4.34 to 11.46 mg kg⁻¹ with a mean value of 7.41 mg kg⁻¹ in Raipur Karchliyan tehsil, 3.98 to 56.30 mg kg⁻¹ with a mean value of 10.34 mg kg⁻¹ in Teonther tehsil, 2.76 to 119.00 mg kg⁻¹ with a mean value of 12.78 mg kg⁻¹ in Mouganj tehsil, 2.23 to 102.30 mg kg⁻¹ with a mean value of 18.82 mg kg⁻¹ in Hanumana tehsil. For the entire Rewa district, available Mn content in soils varied from 2.05 to 127.30 mg kg⁻¹ with a mean value of 14.41 mg kg⁻¹ of soil. None of the samples were tested low in manganese.

Available boron: As evident from the data presented in Table-4 the available B content in soils was found to vary from 0.21 to 2.82 mg kg⁻¹ with a mean value of 1.31 mg kg⁻¹ in Rewa tehsil, 0.61 to 2.66 mg kg⁻¹ with a mean value of 1.15 mg kg⁻¹ in Gudh tehsil, 0.39 to 2.32 mg kg⁻¹ with a mean value of 1.06 mg kg⁻¹ in Sirmor tehsil, 0.79 to 2.44 mg kg⁻¹ with a mean value of 1.56 mg kg⁻¹ in Raipur Karchliyan tehsil, 0.13 to 2.66 mg kg⁻¹ with a mean value of 1.64 mg kg⁻¹ in Teonther tehsil, 0.21 to 2.82 mg kg⁻¹ with a mean value of 1.48 mg kg⁻¹ in Mouganj tehsil, 0.55 to 2.32 mg kg⁻¹ with a mean value of 1.35 mg kg⁻¹ in Hanumana tehsil. For the entire Rewa district, available Mn content in soils varied from 0.13 to 2.82 mg kg⁻¹ with a mean value of 1.34 mg kg⁻¹ of soil. None of the samples were tested low in boron.

The available Zn content varied from 0.11 to 3.18 with mean value 0.69 mg kg⁻¹ in district Rewa district. Considering

TABLE-4
DISTRIBUTION OF AVAILABLE BORON CONTENTS (mg kg⁻¹)
AND ITS PERCENT SAMPLE DEFICIENCY OF REWA DISTRICT

Tehsils	B		
	Range	Mean	PSD
Rewa	0.21-2.82	1.31	0.0
Gudh	0.61-2.66	1.25	0.0
Sirmor	0.39-2.32	1.06	0.0
Raipur Karchuliyan	0.79-2.44	1.56	0.0
Teonther	0.13-2.66	1.64	0.0
Mouganj	0.21-2.82	1.48	0.0
Hanumana	0.55-2.32	1.35	0.0
District Rewa	0.13-2.82	1.34	0.0

0.6 mg kg⁻¹ Zn as critical limit³, 55.88 % of the soils in mixed red and black soils of Rewa district were found to be deficient in available zinc. Available Cu, Fe and Mn in the soil samples varied from 0.23 to 4.88, 2.43 to 115.30 and 2.05 to 127.30 mg kg⁻¹ with mean value of 1.17, 20.87 and 14.41 mg kg⁻¹ in Rewa district, respectively. None of the samples were tested low in Cu and Mn content. Only 2.0 % samples were tested low in Fe content. Available B in the soil samples varied from 0.13 to 2.82 with mean value 1.28 mg kg⁻¹ in Rewa district. None of the soil samples was classified as deficient (< 0.1 mg kg⁻¹). Very little information is available as regards the micronutrients status particularly in mixed red and black soils of Rewa district of Madhya Pradesh. However, similar work has been carried out by Dwivedi *et al.*⁵, Mehra *et al.*⁶ and Singh *et al.*⁷ in different soil types.

Categorization of soils for micronutrients of Rewa district: It was observed that 55.88, 29.41 and 14.71 % samples were found as low, medium and high category, respectively, in case of zinc. As regards copper content in soil 93.62 and 6.38 % samples were found to be in medium and high category, respectively. In respect of Fe content 2.0, 44.10 and 53.90 % samples were found to be in lows, medium and high category. As regards the manganese content in soil 21.56 and 78.44 % samples fall in medium and high category. In case of boron content in soil, 37.75 and 62.25 % samples were found to be in medium and high category, respectively in Rewa district. Considering soil nutrient index (Table-5) soils of Rewa district were found of high status in respect of Fe, Mn and B while of medium fertility status with respect to Cu and low fertility status in case of Zn. The values worked out from nutrient index for Zn, Cu, Fe, Mn and B were 1.59, 2.06, 2.52, 2.78 and 2.62, respectively.

Correlation of micronutrients with soil properties: The relationships of soil pH, organic carbon and CaCO₃ with micronutrients are presented in Tables 6-8. The micronutrient contents had negative association with soil pH thereby indicating that

TABLE-5
CATEGORIZATION OF SOILS IN VARIOUS
CATEGORIES DISTRICT REWA

Micronutrients	Percent samples under classes			Nutrient index	N.I. classes
	Low	Medium	High		
Zn	55.88	29.41	14.71	1.59	Low
Cu	-	93.62	6.38	2.06	Medium
Fe	2.00	44.10	53.90	2.52	High
Mn	-	21.56	78.44	2.78	High
B	-	37.75	62.25	2.62	High

TABLE-6
EFFECT OF pH ON THE AVAILABILITY OF MICRONUTRIENT IN SOIL OF REWA DISTRICT

S. No.	pH	N.S.	P.S	Zn (mg kg ⁻¹)	Mean	Cu (mg kg ⁻¹)	Mean	Fe (mg kg ⁻¹)	Mean	Mn (mg kg ⁻¹)	Mean	B (mg kg ⁻¹)	Mean
1	5.1-5.5	1	0.49	0.84	0.84	1.44	1.44	15.46	15.46	10.16	10.16	0.13	0.13
2	5.6-6.0	8	3.93	0.24-2.77	1.05	0.41-0.77	0.60	7.33-32.2	14.80	5.92-119	29.65	0.21-1.81	0.92
3	6.1-6.5	15	7.35	0.21-1.29	0.67	0.44-1.13	0.76	5.27-103	31.48	2.23-76.3	15.20	0.61-1.92	1.16
4	6.6-7.0	13	6.37	0.15-1.93	0.70	0.38-4.30	1.23	4.61-20.4	11.34	3.05-34.3	10.81	0.39-2.66	1.23
5	7.1-7.5	41	20.08	0.15-3.18	0.79	0.23-4.77	1.38	4.73-106.2	22.97	2.54-127.3	21.00	0.61-2.17	1.34
6	7.6-8.0	123	60.29	0.11-2.77	0.65	0.27-4.88	1.20	2.43-115.3	21.61	2.05-102.3	13.32	0.21-2.82	1.37
7	8.1-8.5	3	1.47	0.46-1.13	0.85	0.72-3.44	1.83	5.54-12.3	8.75	3.12-8.49	6.27	2.66-2.82	2.72
				r = (-) 0.0693, Y = 1.217-0.724X		r = (-) 0.0975, Y = 0.244+0.1876X		r = 0.0391, Y = 7.049+1.8044X		r = (-) 0.0387, Y = 25.4232-1.544X		r = 0.2699**, Y = 0.8314+0.291X	

TABLE-7
EFFECT OF ORGANIC CARBON ON THE AVAILABILITY OF MICRONUTRIENT IN SOIL OF REWA DISTRICT

S. No.	O.C.	N.S.	P.S	Zn (mg kg ⁻¹)	Mean	Cu (mg kg ⁻¹)	Mean	Fe (mg kg ⁻¹)	Mean	Mn (mg kg ⁻¹)	Mean	B (mg kg ⁻¹)	Mean
1	2.1-4.5	84	41.17	0.11-2.33	0.65	0.27-4.77	1.06	4.34-112.30	20.87	2.05-127.30	14.90	0.24-2.66	1.21
2	4.6-7.0	98	48.03	0.11-2.77	0.62	0.33-4.88	1.31	2.43-115.30	20.72	2.23-88.30	14.31	0.13-2.82	1.40
3	7.1-9.5	18	8.83	0.15-2.23	0.93	0.23-4.15	1.30	5.30-87.50	27.01	3.05-102.30	21.23	0.51-2.32	1.27
4	9.6-12.0	4	1.95	0.36-3.18	2.09	0.27-0.85	0.59	5.25-74.20	30.20	4.94-9.11	6.88	1.18-1.81	1.56
				r = 0.2798**, Y = 0.123+0.1104X		r = 0.0128, Y = 1.107+0.0093X		r = 0.0781, Y = 13.683+1.3595X		r = 0.0091, Y = 13.230+0.137X		r = 0.1396*, Y = 1.0252+0.051X	

TABLE-8
EFFECT OF CaCO₃ ON THE AVAILABILITY OF MICRONUTRIENT IN SOIL OF REWA DISTRICT

S. No.	CaCO ₃	N.S.	P.S	Zn (mg kg ⁻¹)	Mean	Cu (mg kg ⁻¹)	Mean	Fe (mg kg ⁻¹)	Mean	Mn (mg kg ⁻¹)	Mean	B (mg kg ⁻¹)	Mean
1	0-5	190	93.13	0.11-3.18	0.69	0.23-4.88	1.16	2.43-115.30	21.12	2.05-127.30	15.14	0.13-2.82	1.32
2	5.1-10	12	5.83	0.18-2.77	0.85	0.27-4.10	1.22	4.87-86.30	22.17	2.67-9.11	4.76	0.68-2.66	1.42
3	10.1-15	2	0.83	0.13-0.70	0.42	0.48-4.00	2.24	5.15-20.30	12.73	2.45-4.67	3.61	0.65-1.02	0.84
				r = (-0.1375*), Y = 0.812-0.0447x		r = 0.1039, Y = 0.950+0.0621x		r = 0.0750, Y = 17.505+1.0743x		r = (-)0.1536*, Y = 19.2279-1.905x		r = (-0.2404**), Y = 1.4844-0.073x	

availability of micronutrients decreases with increase in soil pH. However, the available boron content in soils correlated positively and significant correlation was found with soil pH ($r = 0.2699^{**}$). Such a behaviour was also reported by Singh *et al.*⁸ and Verma *et al.*⁹.

The organic carbon content exhibited significant positive correlation with available Zn ($r = 0.2798^{**}$) and B ($r = 0.1396^{*}$) contents in soil. Available boron content was increased from 1.21 to 1.56 mg kg⁻¹ with increasing range of organic carbon from 2.5 to 15.0 g⁻¹. The availability of boron increased due to formation of strong dial complex of boron with organic matter in soil¹⁰. The positive correlation with organic carbon suggested that the micronutrients form complexes with organic matter and consequentially remained in the forms, easily available to the plants. Further, the CaCO₃ contents had got significant negative correlation with available Zn ($r = -0.1375^{*}$), Mn ($r = -0.1536^{*}$) and B ($r = -0.2404^{**}$) contents in soil. Similar correlations were also reported by Garg and Totawat¹¹.

Conclusion

It is apparent from study that the deficiencies of Zn and Fe were found in 55.9 and 2.0 % samples, however, none of the soils samples were deficient in available Cu, Mn and B. Results indicated that soil pH showed significantly positive correlation with available boron. Further, organic carbon had

a significant and positive relationship with available Zn and B. Hence, organic carbon and soil pH are the main soil characteristics which control micronutrient availability in mixed red and black soil of Rewa district, Madhya Pradesh. The studies suggested that higher organic carbon content in soil leads to protection of crops from micronutrient (Zn and B) deficiencies.

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