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Spatial variability of DTPA-extractable micronutrients and their correlation studies with important soil properties in the soils of Narmada district of Gujrat

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Abstract
A total 125 surface soil samples (0-22.5 cm) were collected from five *talukas* of Narmada district using GPS. The soil samples were analyzed for DTPA extractable micronutrients (Fe, Mn, Zn and Cu). The DTPA-Fe varied from 0.65 to 36.8 mg kg^{-1} with a mean value 8.45 mg kg^{-1}, DTPA-Mn varied from 1.06 to 139.36 mg kg^{-1} with a mean value 22.24 mg kg^{-1}, DTPA-Zn varied from 0.07 to 4.46 mg kg^{-1} with a mean value 0.77 mg kg^{-1} and DTPA-Cu varied from 0.45 to 13.38 mg kg^{-1} with a mean value 11.94 mg kg^{-1}. Out of 125 samples 50.4 percent samples were deficient in DTPA-Fe, 55.2 percent samples were medium in DTPA-Zn and 65.6 percent samples were sufficient in DTPA-Mn content whereas, 100 percent samples were sufficient in DTPA-Cu content. DTPA-Fe (-0.809^{**}), DTPA-Mn (-0.208^{*}), DTPA-Zn (-0.301^{**}) and DTPA-Cu (-0.688^{**}) showed significantly negative correlation with soil pH and DTPA-Fe (0.312^{**}), DTPA-Zn (0.187^{*}) and DTPA-Cu (0.251^{**}) showed significantly positive correlation with soil organic carbon.

Keywords: DTPA extractable micronutrients, GPS, correlation

Introduction
Among the main natural resources like soil, water and climate, soil plays a profound and vital role in influencing the crop productivity as well as cropping pattern of that region. As the natural resources of any country are the national treasure, we need proper planning to make best use of them. Therefore, suitable management practices are urgently needed to preserve the production potential of agricultural lands. So, a renewed attention is being given to soils due to rapidly declined land area for agriculture, declining soil fertility and increasing soil degradation, wrong land use policies and irrational and imbalance use of input (Kanwar, 2004) [4]. Every type of soil differs in terms of its physical, chemical, and mineralogical features, as well as how it responds to use and management. To forecast or estimate the potentials and restrictions of the behavior of the soils under various usage, one can use the information gathered during a soil survey. Micronutrients are important plant nutrients that are only present in minimal amounts in tissue but are crucial for the growth and development of plants. Keeping this in view, present study on GPS based soil testing was done to evaluate the micronutrient (Fe, Mn, Zn, Cu) status in soils of Narmada district of Gujarat, India.

Materials and Methods
Study area
The research region is located in Gujarat's Narmada district between the parallels of 21°23' and 22°05' North Latitude and 73°17' and 73°59' East Longitude. It has a diversified landscape and is in the semi-arid to tropic agro climatic zone. The majority of the soils in the Narmada district are black cotton soil. Hilly areas have light texture soil, while plain areas typically have heavy, black soils.

Collection of soil samples
In five talukas (Tikalwada, Garudeshwar, Nandod, Dediyapada, and Sagbara) in the Narmada district during the summer of 2020, 125 representatives GPS-referenced surface (0-22.5 cm) soil samples were at random taken from farmer fields. Surface (0-22.5 cm) soil samples were taken to the lab and processed according to standard procedure before being labeled properly and stored in clean polythene bags for analysis.

Physico-chemical parameters like $pH_{2.5}$ and $EC_{2.5}$ were determined as per standard methods described by Jackson (1979) [3]. Soil organic carbon was determined by rapid titration method (Walkly and Black, 1934) [8]. The simple correlation among physio chemical properties and available macronutrients were work out as per standard method given by Panse and Sukhatme (1967) [6].

Results and Discussion

The soils of Narmada district are medium acidic to moderately alkaline (pH 5.7 to 8.17) with mean value of 7.23 and values of electrical conductivity varied from 0.04 to 0.74 dS m^{-1}. The organic carbon content in soils varied from 0.27 to 2.83 percent with mean value of 0.86 percent (Table 1).

DTPA extractable micronutrients

DTPA-Fe varied from 0.65 to 36.8 mg kg^{-1} with a mean value 8.45 mg kg^{-1} (Table 1) and was found to be deficient in 50.4 percent samples, 13.6 percent were medium and 36.0 percent samples were high in DTPA-Fe content (Table 2). This wide variation in Fe content in might be due to site-specific Fe application. Correlation study shows that DTPA-Fe was positively and significantly correlated with SOC, DTPA-Mn, DTPA-Zn and DTPA-Cu but significantly and negatively correlated with pH and EC (Table 3).

The values of DTPA-Mn content in soil were varied from 1.06 to 139.36 mg kg^{-1} with the mean value 22.24 mg kg^{-1} (Table 1). Out of the 125 soil samples, 21.6 percent samples were deficient, 12.8 percent were medium and 65.6 percent samples were high in range (Table 2). Correlation study indicated that DTPA-Mn was positively and significantly correlated with DTPA-Fe and DTPA-Cu but significantly and negatively correlated with soil pH (Table 3).

DTPA-Zn varied from 0.07 to 4.46 mg $kg^{-1}$with a mean value 0.77 mg kg^{-1} (Table 1) and was found to be deficient in 24.0 percent samples, 55.2 percent were medium and 20.8 percent samples were high in DTPA-Zn content (Table 2). Correlation study shows that DTPA-Zn was positively and significantly correlated with SOC and DTPA-Fe but significantly and negatively correlated with pH (Table 3).

DTPA-Cu varied from 0.45 to 13.38 mg $kg^{-1}$with a mean value 11.94 mg kg^{-1} (Table 1) and 100 percent samples were found high in DTPA-Cu content (Table 2). Correlation study shows that DTPA-Cu was positively and significantly correlated with SOC, DTPA-Fe and DTPA-Mn but significantly and negatively correlated with pH and EC (Table 3).

Similar results of significantly and/or negative correlations of all or some micronutrients with pH were also documented by Kumar and Babel (2011) [5] and Vijaykumar (2011) [7]. Results of positive and significant simple correlations among DTPA-micronutrients, SOC with available N and DTPA-micronutrients with other parameters like, available P_2O_5 were reported by Athokpam *et al.* (2013) [1] and Bassirani *et al.* (2011) [2].

Table 1: Micronutrient (Fe, Mn, Zn, Cu) status and other soil properties in different *talukas* of Narmada district

Taluka	pH (1:2.5)	EC (1:2.5) dS m^{-1}	SOC (%)	DTPA extractable micronutrient (mg kg^{-1})			
				Fe	Mn	Zn	Cu
Tilakwada	7.44-8.12 (7.78)	0.11-0.35 (0.21)	0.4-1.03 (0.75)	0.91-3.48 (1.84)	1.06-12.06 (5.88)	0.47-1.12 (0.69)	0.45-2.52 (1.23)
Garudeshwar	6.49-8.04 (7.42)	0.08-0.47 (0.27)	0.46-1.8 (0.88)	0.65-13.5 (2.70)	1.09-83.72 (11.30)	0.40-2.42 (0.78)	1.07-4.14 (2.06)
Nandod	6.78-8.17 (7.53)	0.11-0.74 (0.25)	0.4-1.62 (0.79)	0.65-10.60 (4.19)	6.24-73.70 (29.13)	0.23-4.46 (0.86)	1.20-6.93 (4.42)
Dediyapada	6.34-7.93 (7.18)	0.04-0.51 (0.24)	0.27-1.08 (0.63)	5.04-16.38 (11.52)	24.44-139.36 (46.47)	0.20-1.39 (0.54)	2.37-13.38 (6.39)
Sagbara	5.7-7.05 (6.24)	0.05-0.27 (0.13)	0.73-2.83 (1.27)	7.72-36.80 (22.01)	10.22-30.21 (18.42)	0.63-1.35 (0.99)	5.57-10.74 (8.57)
Overall	5.7-8.17 (7.23)	0.04-0.74 (0.22)	0.27-2.83 (0.86)	0.65-36.8 (8.45)	1.06-139.36 (22.24)	0.20-4.46 (0.77)	0.45-13.38 (11.94)
SD	0.63	0.11	0.37	8.82	20.97	0.50	2.49

Table 2: Categorization of micronutrients of surface soils of Narmada district

Micronutrients in irrigated soils (mg kg^{-1})																	
Taluka	No. of samples	DTPA-Fe				DTPA-Mn				DTPA-Zn				DTPA-Cu			
		Range	L	M	H	Range	L	M	H	Range	L	M	H	Range	L	M	H
Tilakwada	25	0.91-3.48 (1.84)	25 (100.0)	0 (0.0)	0 (0.0)	1.06-12.06 (5.88)	13 (52.0)	9 (36.0)	3 (12.0)	0.47-1.12 (0.69)	3 (12.0)	20 (80.0)	2 (8.0)	0.45-2.52 (1.23)	0 (0.0)	0 (0.0)	25 (100.0)
Garudeshwar	25	0.65-13.5 (2.70)	21 (84.0)	2 (8.0)	2 (8.0)	1.09-83.72 (11.30)	14 (56.0)	5 (20.0)	6 (24.0)	0.4-2.42 (0.78)	4 (16.0)	17 (68.0)	4 (16.0)	1.07-4.14 (2.06)	0 (0.0)	0 (0.0)	25 (100.0)
Nandod	25	0.65-10.6 (4.19)	17 (68.0)	6 (24.0)	2 (8.0)	6.24-73.7 (29.13)	0 (0.0)	2 (8.0)	23 (92.0)	0.23-4.46 (0.86)	8 (32.0)	12 (48.0)	5 (20.0)	1.2-4.42 (4.42)	0 (0.0)	0 (0.0)	25 (100)
Dediyapada	25	5.04-16.38 (11.52)	0 (0.0)	8 (32.0	17 (68.)	24.44-139.36 (46.47)	0 (0.0)	0 (0.0)	25 (100.0)	0.07-1.39 (0.54)	15 (60.0)	8 (32.0)	2 (8.0)	2.37-13.38 (6.39)	0 (0.0)	0 (0.0)	25 (100.0)
Sagbara	25	7.72-36.8 (22.01)	0 (0.0)	1 (4.0)	24 (96.0)	10.22-30.21 (18.42)	0 (0.0)	0 (0.0)	25 (100.0)	0.63-1.35 (0.99)	0 (0.0)	12 (48.0)	13 (52.0)	5.57-10.74 (8.57)	0 (0.0)	0 (0.0)	25 (100.0)
Overall Narmada District	125	0.65-36.8 (8.45)	63 (50.4)	17 (13.6)	45 (36.0)	1.06-139.36 (22.24)	27 (21.6)	16 (12.8)	82 (65.6)	0.07-4.46 (0.77)	30 (24.0)	69 (55.2)	26 (20.8)	0.45-13.38 (11.94)	0 (0.0)	0 (0.0)	125 (100.0)

L=Low, M=Medium, H=High, and values in parenthesis ( ) indicates percent soils

Table 3: Simple correlation among different parameters of surface soils of Narmada district

	pH	EC	SOC	DTPA-Fe	DTPA-Mn	DTPA-Zn	DTPA-Cu
pH	1.00						
EC	0.377**	1.00					
SOC	-0.407**	-0.187*	1.00				
DTPA-Fe	-0.809**	-0.278**	0.312**	1.00			
DTPA-Mn	-0.208**	0.01	-0.148	0.246**	1.00		
DTPA-Zn	-0.301**	-0.115	0.187*	0.191*	0.004	1.00	
DTPA-Cu	-0.688**	-0.309**	0.251**	0.757**	0.338**	0.111	1.00

Note: ** and * denote significant at 1% and 5% level respectively

Conclusion

About 64 percent and 33 percent samples owing to low to medium status of DTPA-Fe and DTPA- Mn, respectively, call for their improvement, to overcome plant demand to achieve higher yield and quality of produce due to their essential role. Similarly, 79 percent surface samples with low to medium status of DTPA-Zn from the entire Narmada district need appropriate measures to improve the status of Zn to desired level so as to maintain soil health, improvement of possible crop yield and soil quality. While, 100 percent samples were found high in DTPA-Cu content.

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