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DEPTH-WISE DELINEATION OF DEFICIENCY AND SUFFICIENCY AREA OF MICRONUTRIENT USING GPS-GIS TECHNOLOGY AND THEIR CORRELATION WITH SOIL PROPERTIES OF DAUSA TAHSIL OF RAJASTHAN, INDIA

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ABSTRACT
The present investigation was carried out in Dausa tehsil of Dausa district of Rajasthan during the year 2021 and 2022 to delineate the surface and sub-surface area of deficiency and sufficiency for micronutrient and their corelation with soil properties. A total 242 soil samples at surface (0-15) and sub-surface (15-30 cm) layers from Dausa tehsil were collected using Global Positioning System (GPS). Soils were deficient in Zn, Cu, Fe, and B but sufficient in Mn. The soils were sufficient in Cu (85.95, 73.55 %), Fe (52.07, 24.79 %), Mn (100 %) and B (63.64, 43.80 %), however, deficient (69.42, 90.91 %) in Zn and available S (89.28,95.05 %) content in Dausa tehsil under surface and sub-surface layers respectively. The availability of micronutrient (Fe, Cu, Mn, Zn and B) has positive correlation with OC, EC, CEC silt and clay content of soils, whereas, significant negative correlation with pH, CaCO3, ESP and sand.

KEYWORDS: Correlation, GPS-GIS, Micronutrient, Soil Fertility MAP, Soil Properties

INTRODUCTION
Soil fertility map for a particular area can provide highly beneficial guidance to the farmers, manufacturers and planners as pertaining to the requirement of various fertilizers in the particular season and making projections for increased requirement of fertilizers based on cropping pattern and intensity. When fertility status of a soil is known in terms of soil test values, which could be calibrated into different fertility classes such as low, medium and high (Welch and Wiere, 1987; Rashid and Memon, 1996). Maximum farmers are applied the fertilizers in the fields without prior knowledge of soil fertility status, might be resulted in adverse effects on the soils as well as crops both in terms of nutrient deficiencies and toxicity either by the adequate or over use of fertilizers, respectively (Sharma, 2004). It has been noticed 49 per cent of soils have been found to be deficient in Zn, 15 per cent in Fe, 3 per cent in Cu, 5 per cent in Mn, 33 per cent in B and 13 per cent in Mo. (Singh and Behera, 2011). In hot arid region Rajasthan about 99.4, 48.7, 11.0, 56 and 41 per cent of the area are under low availability class for OC, P, K, Zn and Fe (Mahesh Kumar et al. 2021). Deficiency of micronutrients in Rajasthan soil are 56.5, 9.15,28.28, 34.38 and 2.99 of Zn, Cu, Mn, Fe and B respectively (Sukla et al. 2014). There is still a large gap in knowledge about the spatial-temporal distribution of the available nutrients (macro and micronutrients) in the soils (Singh et al. 2007 and Mahesh Kumar et al. 2018). Systems (GIS) offer a priceless tool for optimizing soil fertility. Using GIS technology enables farmers to increase output, cut expenses, and support the farming sector's overall sustainability (Ravi et al. 2022). Preparing fertility maps to determine nutrient status of a particular region / state / place which helps us to formulate nutrient balance, fertilizer recommendation, suitable soil management activities and finally increased the production and productivity in Rajasthan through fertility MAP.

MATERIALS AND METHODS
Description of the study area
The present investigation was carried out during the year 2021 and 2022 in Dausa tehsil of Dausa district of Rajasthan, situated at an elevation of 333 meters above mean sea level with a latitude of 26.89° N and longitude of 76.33° E in the agroclimatic zone IIIA (semi-arid eastern plains of Rajasthan).

Soil sampling and analysis
A total 242 Geo-referenced surface (0-15) and sub-surface (15-30 cm) soil samples were collected on random basis from different fields of selected villages. The latitude and longitude of sampling sites were recorded with the help of Global Positioning System and GPS readings of sampling sites were mentioned in the MAP. The soil samples were processed and analysed for their nutrient status by using standard analytical methods. The method of Lindsay and Norvell was used to estimate DTPA-extractable micronutrients. After soil samples were shaken with a DTPA extractant (Lindsay and Norvel

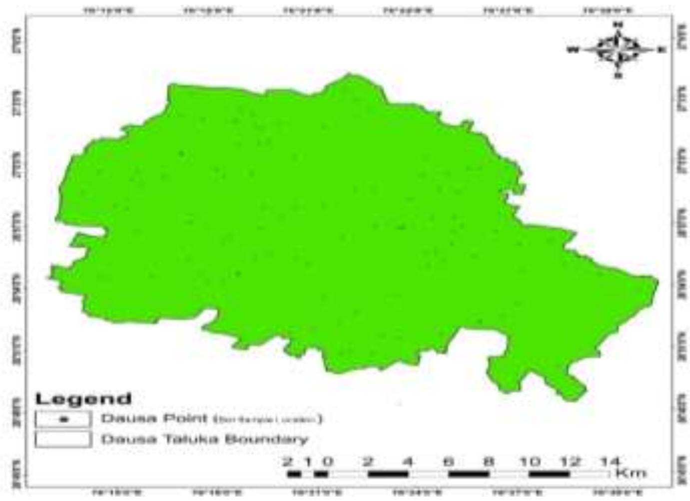
1978). An atomic absorption spectrophotometer with element-specific cathode lamps was used to measure the amounts of micronutrients.

Generation of soil MAP

The data pertaining to different nutrients after analysis was imported in excel file with their coordinates collected from the field. The shape file of the same was created using Arc GIS 9.3 software for mapping. For generation of different nutrients maps, the point shape file was generated. The block wise boundary shape file of the Dausa tehsil was created using toposheet, Survey of India through Arc GIS software. All the data files were imported in Arc GIS for map generation. Spatial analyst tool in Arc GIS 9.3 was used for interpolation method for map generation. The hyper linking of attributes of soil properties of collected samples was done and MAP of the nutrients were generated.

Statistical analysis:

The data was statistically analysed for correlation and standard deviation using the procedure given by Snedecor and Cochran (1967).



Map 1. Details of location of sampling sites of Dausa tehsil.

RESULTS AND DISCUSSION

DTPA Extractable Micronutrients Content in Soil.

DTPA Zinc

The DTPA zinc content of soils were varied from 0.35 to 0.68 and 0.32 to 0.64 mgkg-1 under surface and sub-surface soil samples respectively. (Table 1). The minimum value of DTPA zinc were 0.35 and 0.32 mgkg-1 in Padli (D-42), while maximum value was 0.68 and 0.64 mgkg-1 in Bhaidoli village under surface and sub-surface layers respectively. The mean value, standard deviation and coefficient of variation of DTPA zinc content were 0.54, 0.51 mgkg-1, 0.07, 0.07 and 13.49, 14.41 percent under both the layers respectively. Spatial distribution of DTPA Zinc status also presented in Maps 2 and 3. If soils rich in CaCO3 and alkaline pH, Zn may be precipitated as carbonate and hydroxides under alkaline pH. Therefore, decreased their mobility and solubility. Zinc content was found low in sub-surface soil samples as compared with surface soil. This might be due to decreasing of micronutrients with increasing the depth of soil. Pawar et. al. (2016) also reported that micronutrient decreased with increasing the depth of soil. If soils are calcareous in nature the Zn exists in oxidized state and become low in availability. Similar results were also found by Sharma and Chaudhary (2007), Rajeswar et al. (2009) and Singh et al. (2009). The high zinc deficiency of studied area may be due to that; farmers are not applying Zn to rabi and kharif crops which increased zinc deficiency. Significantly positive correlation of available zinc with OC (r = 0.797**, 0.718**), EC (r = 0.476**, 0.425**) and clay (r = 0.271*,0.276*) but positive non-significant with CEC (r = 0.151, 0.163) and silt content (r = 0.027, 0.081). Significantly negative correlation with pH (r = - 0.730**, - 0.702**), ESP (r = - 0.468**, - 0.454**) and CaCO3, (r = - 0.455**, - 0.514**) and negative but non-significant with sand (r = - 0.162, - 0.180) under surface and sub-surface layer respectively. (Table 2 and 3). It concludes that zinc was significantly and positively correlated with organic carbon and EC of soils (Maji et al., 1993 and Nazif et al., 2006). Similar relationship between DTPA -Zn and pH, OC and CaCO3 was also reported by Jena et al. (2008), Kumar et al. (2009), Bassirani et. al. (2011), Kumar et. al. (2016).

DTPA- Copper

The data presented in table 1 revealed that DTPA -Cu content of soils were varied from 0.13 to 0.45 and 0.11 to 0.42 mgkg-1 under surface and sub- surface layers respectively. The minimum value (0.13 and 0.11 mgkg-1) of DTPA -Cu were observed in Kaableshwar (D-44) village. While, maximum value of DTPA-Cu (0.45 and 0.43 mgkg-1) were observed in Khedi (D-104) village under both the layers respectively. The mean value, standard deviation and coefficient of variation of DTPA copper content were 0.29, 0.27 mgkg-1; 0.08, 0.08 and 26.63, 29.63 per cent under both the layers respectively. Spatial distribution of DTPA -Cu status also presented in Maps 4 and 5. Similar results for DTPA copper of soils were also suggested by Joshi and Dhir (1983). The copper content in soil was decreased with increased the depth of soil. These results are supported with Chhibba et. al. (2007), Singh et al. (2008), Bassirani et. al. (2011), Kumar et. al. (2016) and Pawar et.al. (2016). Significantly positive correlation of available copper with OC (r = 0.683**, 0.628**), EC (r = 0.315**, 0.299**) and clay (r = 0.166*, 0.199*). CEC (r = 0.104, 0.110) and silt content positive but non-significant (r = 0.092, 0.037). Significantly negative correlation with pH (r = - 0.683**, - 0.628**), ESP (r = - 0.554*, - 0.563**) and CaCO3, (r = - 0.451**, - 0.418**) and negative but non-significant with sand (r = - 0.090, - 0.086) under surface and sub-surface layers respectively. (Table 2.1 and 2.2). Maji et al., (1993) and Yadav and Meena (2009), Meena et al., (2006), Kumar et al., (2009) and Kumar et al., (2011) reported the same findings.

DTPA -Manganese

The data presented in table 1 also revealed that DTPA Mn content of soils were varied from 2.10 to 5.65 and 1.90 to 5.12 mgkg-1 under surface and sub- surface layers respectively. The minimum values (2.10 and 1.90 mgkg-1) were observed in Shrirampura (D-119) and Jhaiharwala (D-26) villages. While, maximum values were observed (5.65 and 5.12 mgkg-1) in Teetarwal Kala (D-77) and Khedi (D-104) villages under both the layers respectively. The mean value, standard deviation and coefficient of variation were 3.23, 2.96 mgkg-1; 0.87, 0.79 and 26.77, 26.75 per cent under 0-15 and 15-30 depth respectively. Spatial distribution of DTPA-Mn status also presented in Maps 6 and 7. DTPA manganese content were higher at surface layer as compared with sub-surface layer. Singh et al. (2008), Bassirani et. al. (2011), Kumar et. al. (2016) and Pawar et.al. (2016) also reported that micronutrient decreased with increasing the depth of soil. Significantly positive correlation with DTPA- Mn with EC (r = 0.399**, 0.375**), OC (r = 0.827**, 0.672**), clay (r = 0.224*, 0.223*). CEC (r = 0.136, 0.138) and silt content (r = 0.149, 0.153 under surface) positive but non-significant. Significantly negative correlation with pH (r = - 0.764**, - 0.657**), ESP (r = - 0.395**, - 0.382**) and CaCO3, (r = - 0.439**, - 0.455**) while, sand negative but non-significant (r = -0.208, -0.158) under surface and sub-surface layers respectively (table 2.1 and 2.2). Such observation also recorded by Kumar et al. (2009), Andrabi and Shah (2010), Kumar et al. (2011) and Chaudhari et al. (2012).

DTPA- Iron

The data presented in table 1 revealed that DTPA-Fe content of soils were varied from 3.48 to 5.90 and 3.15 to 5.47 mgkg-1 under 0-15 and 15-30 cm depth respectively. The minimum value (3.48 and 3.15 mgkg-1) were observed in Bane Ka Barkeda (D-14) and Bheekli (D-12) villages. While, maximum value of DTPA-Fe were observed (5.90 and 5.47 mgkg-1) in Sainthal (D-71) and Bhaidoli (D-108) villages under both the layers respectively. The mean value, standard deviation and coefficient of variation of DTPA iron were 4.54, 4.19 mgkg-1; 0.51, 0.51 and 11.17, 12.07 per cent under 0-15 and 15-30 cm depth respectively. Spatial distribution of DTPA -Fe status also presented in Maps 8 and 9. Iron content decreased with increasing the depth of soil because low CEC, high pH, loamy sand texture, content of CaCO3 and low organic matter content under sub-surface soil. Similar results also reported by Meena et al., 2006, Jiang et. al. 2009, Yadav and Meena, 2009, Pawar et.al. 2016 and Kumar A. 2020. The soil pH affects the availability of iron content in soil. Precipitation of Fe2+ by calcium carbonate and reduce the availability of iron content in soil (Sharma et al., 2001). In surface soil DTPA iron content has no regular pattern of distribution (Nayak et al., 2002). That type of variation in DTPA -Fe content may be due to the cropping pattern and soil management practices adopted by farmers. Significantly positive correlation of DTPA-Fe with OC (r = 0.636**, 0.391**), EC (r = 0.153*, 0.114*), clay (r = 0.140*, 0.119*) and positive but non-significant with silt content (r = 0.111,0.027) and CEC (r = 0.091, 0.080). Significantly negative correlation with pH (r = - 0.550**, - 0.472**), ESP (r = - 0.232*, - 0.155*), CaCO3, (r = - 0.343**, - 0.367**), negatively but non-significant with sand (r = -0.141, - 0.070) under both the layers respectively. (Table 2.1 and 2.2). Similar results were also observed by Sharma and Choudhary 2007, Jena et al., 2008 and Andrabi and Shah 2010 and Kumar et al. 2011.

Table 1. Micronutrients status (0-15 and 15-30 cm depth) of soils of Dausa tehsil.

S. No.	Sample code No	Available Micronutrients (ppm)									
		Zn		Fe		Mn		Cu		B	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	2	11	12	13	14	15	16	17	18	19	20
1	D1	0.59	0.55	4.25	3.88	3.26	3.20	0.38	0.37	0.56	0.54
2	D2	0.63	0.60	3.60	3.45	3.28	3.21	0.39	0.38	0.57	0.54
3	D3	0.51	0.46	3.76	3.65	3.19	3.14	0.32	0.30	0.50	0.47
4	D4	0.56	0.53	4.51	3.91	3.25	3.20	0.35	0.33	0.52	0.47
5	D5	0.61	0.59	4.40	4.20	3.30	3.10	0.38	0.37	0.62	0.61
6	D6	0.35	0.33	4.05	3.40	2.17	2.10	0.26	0.23	0.35	0.34
7	D7	0.47	0.45	4.40	4.31	2.19	2.01	0.27	0.27	0.45	0.43

S. No.	Sample code No	Available Micronutrients (ppm)									
		Zn		Fe		Mn		Cu		B	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	2	11	12	13	14	15	16	17	18	19	20
8	D8	0.50	0.49	4.35	3.75	2.18	2.02	0.34	0.32	0.49	0.46
9	D9	0.49	0.45	4.05	3.30	2.50	2.30	0.33	0.29	0.47	0.45
10	D10	0.53	0.49	4.15	3.55	2.22	2.14	0.32	0.30	0.49	0.46
11	D11	0.64	0.59	3.81	3.80	3.25	3.12	0.40	0.39	0.59	0.55
12	D12	0.61	0.58	3.55	3.15	3.10	2.00	0.38	0.35	0.55	0.53
13	D13	0.58	0.57	4.47	3.91	3.80	3.60	0.36	0.34	0.54	0.51
14	D14	0.60	0.56	3.48	3.40	3.85	3.65	0.41	0.41	0.56	0.52
15	D15	0.54	0.52	4.05	3.18	3.81	3.62	0.40	0.38	0.55	0.54
16	D16	0.47	0.44	4.50	4.50	3.78	3.58	0.33	0.31	0.51	0.46
17	D17	0.44	0.43	4.15	4.10	3.10	3.00	0.32	0.31	0.49	0.44
18	D18	0.39	0.37	4.07	3.75	2.18	2.10	0.17	0.14	0.37	0.33
19	D19	0.41	0.38	5.11	5.05	2.26	2.00	0.21	0.16	0.39	0.35
20	D20	0.61	0.58	4.80	4.47	3.50	2.80	0.39	0.36	0.50	0.48
21	D21	0.64	0.60	5.46	5.21	3.75	2.60	0.40	0.39	0.57	0.56
22	D22	0.54	0.53	4.55	4.14	3.40	2.80	0.37	0.36	0.56	0.53
23	D23	0.57	0.52	4.50	4.27	3.42	2.80	0.40	0.38	0.55	0.54
24	D24	0.50	0.46	4.10	3.96	2.19	2.00	0.22	0.21	0.42	0.38
25	D25	0.57	0.53	4.61	4.45	3.11	2.80	0.38	0.37	0.51	0.49
26	D26	0.49	0.46	4.05	3.85	2.23	1.90	0.20	0.15	0.38	0.34
27	D27	0.52	0.50	4.07	3.75	2.25	2.00	0.21	0.19	0.36	0.31
28	D28	0.56	0.54	4.20	4.10	3.15	2.98	0.34	0.30	0.51	0.48
29	D29	0.47	0.43	4.16	4.11	3.10	2.95	0.27	0.23	0.37	0.35
30	D30	0.57	0.55	4.15	4.09	3.13	2.90	0.29	0.27	0.48	0.45
31	D31	0.51	0.46	4.09	3.96	2.35	2.10	0.21	0.18	0.39	0.35
32	D32	0.55	0.52	4.14	4.01	3.22	3.10	0.33	0.30	0.49	0.48
33	D33	0.57	0.54	4.57	4.47	3.31	3.20	0.32	0.31	0.52	0.48
34	D34	0.60	0.58	4.90	4.27	3.35	3.20	0.34	0.30	0.56	0.50
35	D35	0.57	0.56	4.70	4.25	3.37	2.50	0.33	0.27	0.52	0.47
36	D36	0.40	0.38	4.11	3.93	2.46	2.30	0.31	0.30	0.38	0.32
37	D37	0.60	0.55	5.32	4.57	3.65	3.40	0.36	0.35	0.55	0.51
38	D38	0.58	0.56	5.05	4.67	3.69	3.50	0.35	0.30	0.54	0.49
39	D39	0.56	0.55	4.83	4.03	3.22	3.00	0.37	0.33	0.50	0.46

S. No.	Sample code No	Available Micronutrients (ppm)									
		Zn		Fe		Mn		Cu		B	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	2	11	12	13	14	15	16	17	18	19	20
40	D40	0.52	0.45	4.20	3.90	2.90	2.70	0.25	0.24	0.43	0.40
41	D41	0.63	0.54	4.93	4.67	2.20	2.10	0.28	0.24	0.52	0.49
42	D42	0.36	0.32	4.15	4.13	2.12	2.00	0.33	0.30	0.34	0.30
43	D43	0.53	0.49	4.10	3.50	2.10	2.01	0.21	0.17	0.32	0.31
44	D44	0.48	0.43	4.11	3.85	2.20	2.10	0.13	0.11	0.36	0.31
45	D45	0.44	0.38	4.25	3.47	2.15	2.00	0.19	0.17	0.39	0.35
46	D46	0.61	0.59	5.08	4.90	3.25	3.00	0.18	0.13	0.58	0.58
47	D47	0.61	0.58	4.84	4.05	3.34	3.16	0.31	0.28	0.52	0.48
48	D48	0.62	0.58	4.29	4.04	3.32	3.14	0.30	0.29	0.50	0.45
49	D49	0.54	0.49	4.10	4.04	2.17	2.00	0.19	0.17	0.34	0.31
50	D50	0.63	0.59	4.75	4.09	3.30	3.20	0.34	0.33	0.56	0.52
51	D51	0.57	0.53	4.84	3.90	3.12	3.00	0.29	0.27	0.51	0.46
52	D52	0.51	0.47	4.11	4.10	2.24	2.10	0.18	0.16	0.35	0.35
53	D53	0.51	0.48	4.51	4.18	2.44	2.30	0.23	0.19	0.51	0.47
54	D54	0.62	0.59	5.55	5.35	4.36	4.20	0.40	0.37	0.58	0.55
55	D55	0.57	0.52	4.65	4.25	3.35	3.10	0.39	0.36	0.52	0.48
56	D56	0.48	0.43	4.60	4.10	2.45	2.41	0.25	0.23	0.51	0.47
57	D57	0.61	0.58	5.29	5.03	3.33	3.10	0.36	0.34	0.58	0.49
58	D58	0.62	0.59	4.55	4.33	3.15	3.00	0.34	0.28	0.54	0.51
59	D59	0.41	0.38	4.05	3.90	2.20	2.10	0.18	0.14	0.34	0.31
60	D60	0.59	0.55	4.51	3.21	2.90	2.80	0.26	0.22	0.52	0.47
61	D61	0.49	0.44	4.07	4.00	2.25	2.10	0.20	0.19	0.38	0.38
62	D62	0.51	0.48	4.10	3.22	2.61	2.40	0.21	0.19	0.38	0.35
63	D63	0.52	0.49	4.16	3.80	2.34	2.30	0.20	0.20	0.39	0.36
64	D64	0.56	0.53	4.13	4.05	3.15	3.00	0.23	0.21	0.52	0.47
65	D65	0.61	0.55	4.60	4.05	3.40	3.20	0.28	0.24	0.56	0.52
66	D66	0.36	0.33	4.09	3.90	2.25	2.10	0.21	0.19	0.31	0.30
67	D67	0.55	0.49	4.15	4.10	3.16	3.00	0.21	0.18	0.55	0.55
68	D68	0.41	0.39	4.06	3.21	2.60	2.40	0.14	0.13	0.35	0.31
69	D69	0.43	0.37	4.10	3.93	2.70	2.10	0.19	0.17	0.45	0.42
70	D70	0.60	0.59	5.11	4.81	4.37	3.20	0.38	0.34	0.54	0.50
71	D71	0.61	0.58	5.90	4.94	3.34	3.10	0.41	0.36	0.55	0.55

S. No.	Sample code No	Available Micronutrients (ppm)									
		Zn		Fe		Mn		Cu		B	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	2	11	12	13	14	15	16	17	18	19	20
72	D72	0.57	0.56	5.20	4.80	3.50	3.30	0.37	0.32	0.52	0.48
73	D73	0.56	0.51	4.65	4.10	3.52	3.32	0.36	0.32	0.51	0.46
74	D74	0.50	0.46	4.08	4.04	3.15	3.10	0.34	0.30	0.48	0.42
75	D75	0.46	0.45	4.27	4.15	3.26	3.12	0.31	0.31	0.51	0.47
76	D76	0.41	0.38	5.15	4.80	2.62	2.50	0.15	0.12	0.42	0.37
77	D77	0.59	0.55	5.81	4.97	5.65	4.50	0.42	0.38	0.48	0.42
78	D78	0.61	0.56	5.11	4.92	5.30	5.10	0.36	0.36	0.42	0.38
79	D79	0.62	0.59	5.10	5.08	5.36	5.12	0.38	0.35	0.55	0.51
80	D80	0.60	0.56	5.45	5.13	4.25	4.16	0.36	0.33	0.56	0.53
81	D81	0.59	0.55	5.67	4.07	5.31	4.10	0.40	0.39	0.52	0.49
82	D82	0.57	0.53	4.57	4.43	4.15	4.05	0.34	0.29	0.54	0.50
83	D83	0.54	0.51	4.15	4.05	3.29	3.20	0.29	0.25	0.48	0.45
84	D84	0.61	0.57	4.17	3.80	3.40	3.10	0.31	0.27	0.51	0.48
85	D85	0.58	0.56	4.50	4.10	3.26	3.01	0.27	0.24	0.53	0.50
86	D86	0.63	0.62	4.90	4.73	4.24	3.14	0.36	0.36	0.51	0.47
87	D87	0.62	0.61	4.57	4.27	3.30	2.16	0.34	0.32	0.58	0.53
88	D88	0.48	0.45	4.20	3.94	2.36	2.18	0.25	0.22	0.54	0.50
89	D89	0.61	0.60	4.87	4.41	4.35	4.15	0.25	0.21	0.59	0.50
90	D90	0.56	0.53	4.55	4.15	4.33	4.14	0.27	0.23	0.55	0.48
91	D91	0.62	0.60	5.50	5.05	4.59	4.26	0.29	0.25	0.60	0.49
92	D92	0.56	0.53	4.05	3.70	3.32	3.20	0.19	0.18	0.51	0.46
93	D93	0.59	0.55	4.57	4.03	4.32	4.20	0.29	0.26	0.55	0.49
94	D94	0.60	0.59	5.30	5.07	4.23	3.60	0.30	0.27	0.60	0.56
95	D95	0.58	0.51	4.65	4.17	4.35	3.21	0.35	0.32	0.50	0.45
96	D96	0.65	0.62	5.23	4.90	4.34	4.10	0.34	0.34	0.57	0.54
97	D97	0.46	0.45	4.15	4.00	2.25	2.00	0.19	0.18	0.49	0.49
98	D98	0.43	0.42	4.11	4.05	2.16	2.00	0.18	0.15	0.46	0.40
99	D99	0.45	0.42	4.05	4.03	2.20	2.12	0.17	0.13	0.45	0.41
100	D100	0.57	0.54	5.14	4.90	4.30	4.15	0.36	0.35	0.54	0.49
101	D101	0.51	0.46	4.61	4.40	3.18	3.01	0.20	0.19	0.56	0.47
102	D102	0.50	0.46	4.50	4.40	2.20	2.02	0.19	0.17	0.50	0.47
103	D103	0.58	0.55	4.61	4.22	3.28	3.08	0.24	0.19	0.56	0.51

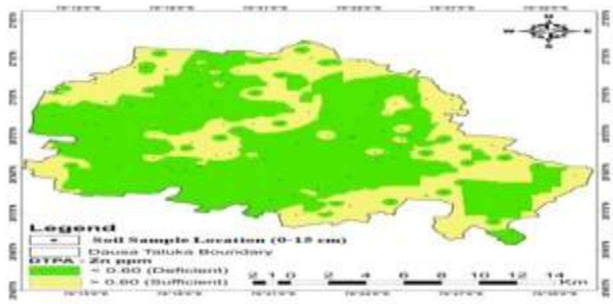
S. No.	Sample code No	Available Micronutrients (ppm)									
		Zn		Fe		Mn		Cu		B	
		0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	2	11	12	13	14	15	16	17	18	19	20
104	D104	0.61	0.57	5.04	4.21	5.32	5.10	0.45	0.42	0.66	0.63
105	D105	0.41	0.39	4.54	4.20	2.65	2.45	0.18	0.17	0.51	0.46
106	D106	0.63	0.60	5.45	5.20	4.15	3.01	0.29	0.27	0.61	0.57
107	D107	0.57	0.52	5.56	5.24	4.18	3.50	0.33	0.30	0.63	0.59
108	D108	0.68	0.64	5.59	5.47	5.20	4.90	0.34	0.32	0.55	0.51
109	D109	0.63	0.61	4.93	5.08	5.39	5.10	0.36	0.35	0.56	0.49
110	D110	0.57	0.53	4.56	4.26	3.30	3.05	0.31	0.29	0.46	0.42
111	D111	0.56	0.52	5.20	4.90	4.50	4.12	0.39	0.37	0.57	0.41
112	D112	0.44	0.42	4.05	3.75	2.31	2.02	0.19	0.17	0.45	0.43
113	D113	0.55	0.51	4.15	4.10	2.30	2.11	0.20	0.18	0.46	0.45
114	D114	0.56	0.52	4.47	4.21	3.25	3.10	0.21	0.19	0.50	0.49
115	D115	0.67	0.61	4.55	4.14	3.30	3.03	0.24	0.21	0.56	0.49
116	D116	0.57	0.53	4.56	4.40	3.54	3.20	0.25	0.22	0.52	0.42
117	D117	0.41	0.37	4.14	4.06	2.15	2.10	0.20	0.18	0.46	0.39
118	D118	0.49	0.45	4.24	4.16	2.28	2.10	0.19	0.19	0.51	0.45
119	D119	0.51	0.47	4.15	3.80	2.10	2.00	0.21	0.18	0.53	0.43
120	D120	0.60	0.59	4.57	3.83	3.45	3.10	0.25	0.24	0.58	0.48
121	D121	0.61	0.59	4.78	3.77	3.42	3.30	0.26	0.23	0.56	0.46
Range	Maximum	0.68	0.64	5.90	5.47	5.65	5.12	0.45	0.42	0.66	0.63
	Minimum	0.35	0.32	3.48	3.15	2.10	1.90	0.13	0.11	0.31	0.30
	Mean	0.54	0.51	4.54	4.19	3.23	2.96	0.29	0.27	0.50	0.46
	SD	0.07	0.07	0.51	0.51	0.87	0.79	0.08	0.08	0.08	0.07
	CV (%)	13.49	14.41	11.17	12.07	26.77	26.75	26.63	29.63	15.07	15.93

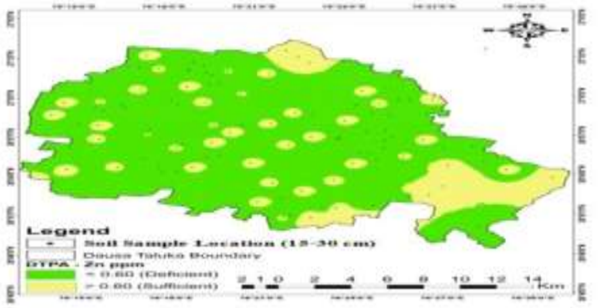
Table 2 Correlation between various soil properties and micronutrient status of soils of Dausa tehsil (0-15 cm depth)

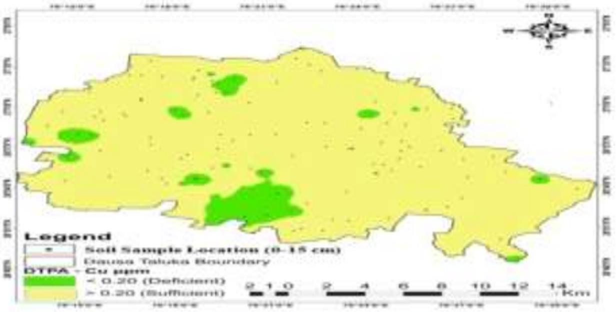
Soil properties	pH	EC	OC	CaCO3	CEC	ESP	Sand	Silt	Clay
Zn	-0.730**	0.476**	0.797**	-0.455**	0.151	-0.468**	-0.162	0.027	0.271*
Fe	-0.550**	0.153*	0.636**	-0.343**	0.091	-0.232*	-0.141	0.111	0.140*
Mn	-0.764**	0.399**	0.827**	-0.439**	0.136	-0.395**	-0.208	0.149	0.224*

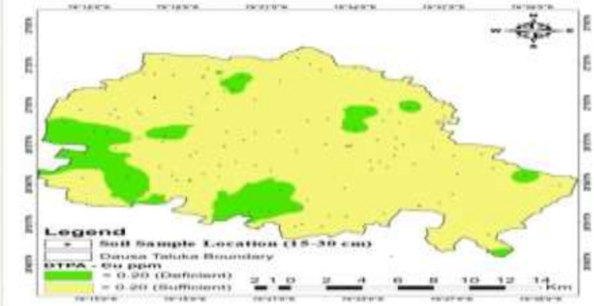
Cu	-0.683**	0.315**	0.765**	-0.451**	0.104	-0.554**	-0.090	0.092	0.166*
B	-0.695**	0.416**	0.791**	-0.464**	0.176	-0.362**	-0.233	0.123	0.298*

** Significant at 5 per cent level of significance* *** Significant at 1 per cent level of significance*



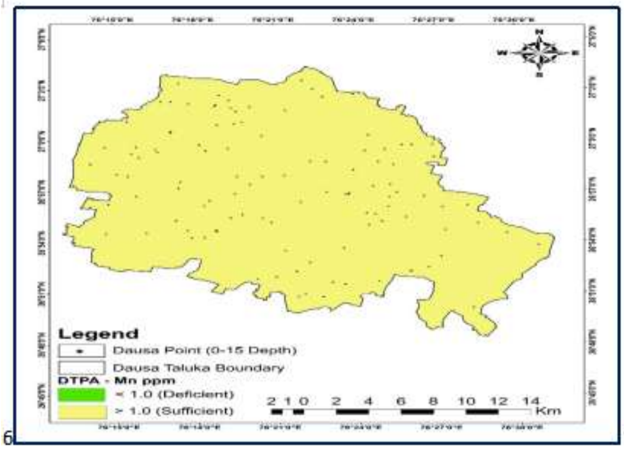
3






5

MAPs 2,3 and 4,5 Spatial distributions of DTPA-Zn and Cu of (0-15 and 15-30 cm depth) soils of Dausa tehsil.

6


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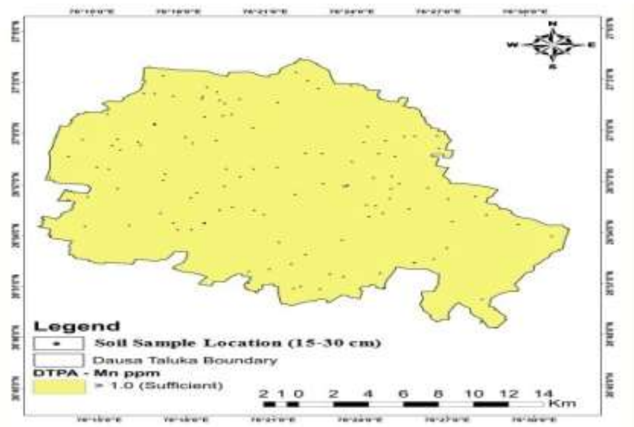
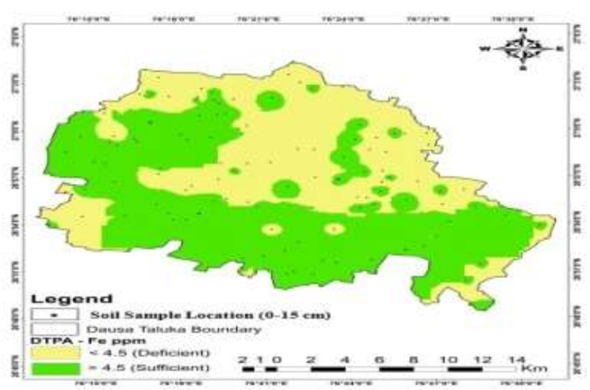
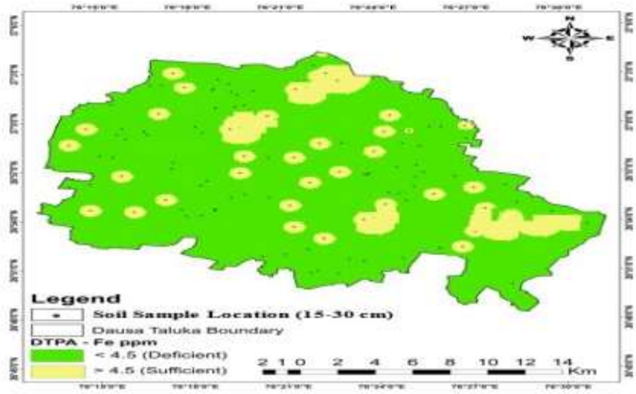


8


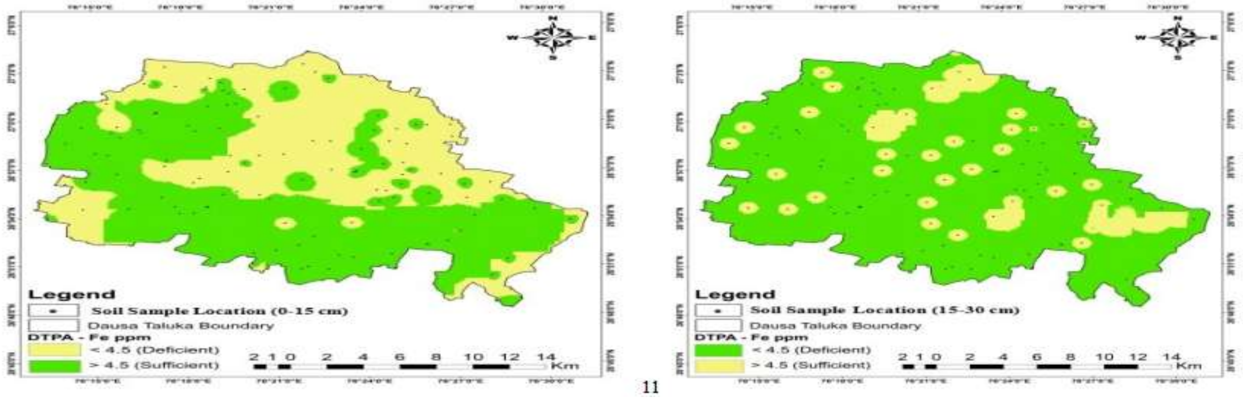
9


MAPs 6,7 and 8,9 Spatial distributions of DTPA-Mn and Fu of (0-15 and 15-30 cm depth) soils of Dausa tehsil.

Table 3 Correlation between various soil properties and micronutrient status of soils of Dausa tehsil (15-30 cm depth)

Soil properties	pH	EC	OC	CaCO3	CEC	ESP	Sand	Silt	Clay
Zn	-0.702**	0.425**	0.718**	-0.514**	0.163	-0.454**	-0.180	0.081	0.276*
Fe	-0.472**	0.114*	0.391**	-0.367**	0.080	-0.155*	-0.070	0.027	0.119*
Mn	-0.657**	0.375**	0.672**	-0.455**	0.138	-0.382**	-0.158	0.153	0.223*
Cu	-0.628**	0.299**	0.715**	-0.418**	0.110	-0.563**	-0.086	0.037	0.199*
B	-0.633**	0.452**	0.683**	-0.389**	0.147	-0.334**	-0.196	0.137	0.252*

** Significant at 5 per cent level of significance* *** Significant at 1 per cent level of significance*



11

MAPs 10 and 11 Spatial distributions of Hot water-soluble Boron (0-15 and 15-30 cm depth) of soils of Dausa tehsil.

Hot-water Soluble -Boron

The data presented in table 1 also revealed that hot water-soluble boron content of soils of were varied from 0.31 to 0.66 and 0.30 to 0.63 mgkg-1 under 0-15 and 15-30 cm depth respectively. The minimum values (0.31 and 0.30 mgkg-1) were observed in Hajya Ka Baas (D-66) and Paadli (D-42) villages. While, maximum values of Boron were observed (0.66 and 0.63 mgkg-1) in Khedli (D-104) village under both the layers respectively. The mean value, standard deviation and coefficient of variation of hot water-soluble boron were 0.50, 0.46 mgkg-1; 0.08, 0.07 and 15.07, 15.93 per cent under surface (0-15 cm) and sub- surface (15-30 cm) layers respectively. Spatial distribution of Hot – water soluble B status also presented in Maps 10 and 11. Hot water-soluble boron content decreased with increasing the depth of soil because low CEC, high pH, loamy sand texture, content of CaCO3 and low organic matter content under surface and sub-surface soil. Similar results were also reported by Sakal et al., 1986, Singh et al., 1991, Sharma et al., 2003, Meena et al., 2006, Jiang et. al. 2009, Yadav and Meena, 2009, Pawar et.al. 2016 and Kumar Abhisek 2020. It gave significantly positive correlation with OC (r = 0.791**, 0.683**), EC (r = 0.416**, 0.452**), clay (r = 0.298*, 0.252*) positive but non- significant with silt (r = 0.123, 0.137) and CEC (r = 0.176, 0.147). Whereas, significantly negative correlation with pH (r = - 0.695**, - 0.633**), ESP (r = - 0.362**, – 0.334**), CaCO3, (r = - 0.464**, - 0.389**) and negatively non-significant with sand (r = - 0.233, - 0.196) under 0-15 and 15-30 cm depth respectively. (Table 2 and 3). The similar results were observed by Yadav and Meena (2009). Many other scientists found that coarse textured soil contained less hot water-soluble boron as compare to fine texture soils (Singh and Randhawa 1977 and Sharma and Bajwa1989). The availability of boron increases with increases in organic carbon content and this might be due to because, its forms soluble complexes with organic matter through absorption.

Sufficient and deficient levels of micronutrient

Data presented in table 4 indicated that DTPA-Zn, 69.42 and 90.91 per cent samples were deficient. While, 30.58 and 9.09 per cent samples were in sufficient category under surface (0-15 cm) and sub-surface (15.30 cm) layers respectively. As an about Cu, 14.05 and 26.45 per cent samples were deficient and 85.95 and 73.55 per cent were in sufficient categories of 0-15 and 15-30 cm depth of soil respectively. As regarding about Fe, 47.93 and 75.21 per cent samples were deficient and 52.07 and 24.79 per cent samples were in sufficient categories under both the layers respectively. For DTPA-Mn, no anyone sample found in deficient category all the soil samples found (100 per cent) in sufficient category of surface and sub- surface soil samples respectively, as suggested by Lindsay and Norvell (1978). However, in case of Hot water-soluble Boron 36.36 and 56.20 per cent samples were deficient and 63.64 and 43.80 per cent samples were in sufficient categories of surface (0-15 cm) and sub- surface (15-30 cm) layers respectively. As suggested by Singh et al. (2007), the soils of Rajasthan have been reported deficient in Zn and Fe and sufficient in Mn, Cu and B by Gathala et al. (2004). The deficiency of Fe and Zn of studies area is of major among all the micronutrients. Such results also supported by Yadav and Meena (2009), Bhanwaria et al. (2011) and Bhanwaria et al. (2015). Such variation in distribution of nutrient value in studies area may be due to different soil management practices including variation in fertilizer application under different cropping systems of the district. The moderate variation was also attributed to the intrinsic factor (soil forming process) and extrinsic factors (soil fertilization and cultivation practices). Similar results were also reported by Reza et al., (2019).

Table 4 Sufficient and deficiency level of micronutrient in soils of Dausa tehsil

DTPA micronutrients	Critical value (mgkg-1)	Deficient (%)		Sufficient (%)		Reference
		0-15cm	15-30cm	0-15cm	15-30cm	
Zn	0.6	84 (69.42%)	110 (90.91%)	37 (30.58%)	11 (9.09%)	Lindsay and Norvell (1978)
Cu	0.20	17 (14.05%)	32 (26.45%)	104 (85.95%)	89 (73.55%)	
Fe	4.5	58 (47.93)	91 75.21%)	63 (52.07%)	30 (24.79%)	
Mn	2.0	-	-	121 (100%)	121 (100%)	Katyal and Rattan (2003)
B	0.5	44 (36.36)	68 (56.20%)	77 (63.64%)	53 (43.80%)	John et al (1975)

CONCLUSION

The soils were sufficient in Cu (85.95, 73.55 %), Fe (52.07, 24.79 %), Mn (100 %) and B (63.64, 43.80%). While, DTPA-Mn 100 per cent soil samples were found in sufficient category. However, deficient (69.42, 90.91 %) in Zn content under surface and sub- surface layers respectively. The availability of micronutrient (Fe, Cu, Mn, Zn and B) has positive correlation with OC, EC, CEC silt and clay content of soils, whereas, significant negative correlation with pH, $CaCO_3$, ESP and sand. Micronutrients are decreasing with increasing the depth of soil.

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Authors' contribution

Author P C Bairwa designed the study, performed the analysis and wrote the first draft of the manuscript. K K Sharma, Rani Saxena, B R Meena and B S Dhakad check the analytical data. R. Sammauria, and R. S., Meena improves in draft. C Kumawat and Jogendra Singh managed the literature searches. All authors read and approved the final manuscript.

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