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Fertility status of soils in tank command areas of North Karnataka

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Abstract: A massive soil-testing programme was undertaken under the Karnataka Community Based Tank Management Project to create awareness about soil health among the farmers. Soil samples from command areas of 910 tanks from four agro-climatic zones covering 46 talukas belonging to ten project districts of north Karnataka were analyzed for pH, organic carbon, available P_2O_5 and K_2O and DTPA extractable Zn and Fe. The results indicated that soils of transition zone (Zone 1 & 8) were neutral (7.22 and 6.93, respectively), and that of northern dry zone (Zone 3) were alkaline (7.94) and that of hilly zone (Zone 9) were acidic (6.39) in pH. Low organic carbon soils comprised 57 per cent in Zone 2 & 3, whereas soils with medium organic carbon were predominant in Zone 1, 8 and 9. Sixty five percent of soil samples recorded medium available P_2O_5 in Zone 8 compared to predominance of low P_2O_5 in other zones representing both dry and heavy rainfall areas. Similarly, Zone 8 soils were predominantly high and soils of other zones were medium in available K_2O. DTPA extractable zinc was predominantly deficient in soils of Zone 1; about half of the samples were deficient in Zone 2 & 3 and zone 8, and predominantly sufficient in Zone 9. With respect to iron, 50 per cent of Zone 1 soils were deficient whereas soils of other zones were nearly sufficient. Soil fertility maps were prepared using taluka as a unit based on predominant class for that taluka. The variability of Zone 2 & 3 soils with respect to organic carbon and available P_2O_5 and K_2O was high and the lowest variability for these parameters was observed in Zone 8.

Key words: Micronutrients, North Karnataka, Soil fertility status, Tank command area

Introduction

Soil is a reservoir of all the essential plant nutrients. Therefore, it is necessary to maintain the fertility status of soil for sustainable crop production in the backdrop of heavy depletion due to intensive cultivation with high yielding varieties/hybrids, especially under irrigation. Small-scale soil fertility mapping was attempted during the course of preparation of soil map for Karnataka on 1:250000 scale by sampling soils at 10 km grid (Shivaprasad *et al.,* 1998). More recently, a soil fertility atlas of Karnataka was prepared under the Bhoochetana programme initiated by the Government of Karnataka (Wani *et al.,* 2011). A massive soil-testing programme was undertaken under the Karnataka Community Based Tank Management Project to create awareness about soil health among the farmers and to persuade them to adopt soil-test based fertilizer application. Therefore, from the inception of the project in 2003 till 2011, a number of soil samples from tank commands of the ten project districts from north Karnataka were analyzed. The huge data that emanated from the project districts or a portion thereof has been grouped under four agro-climatic zones of north Karnataka and presented in this paper. Further, hypothesizing that the soil health from command areas and surrounding areas are similar, the data is extrapolated to prepare the fertility map of project taluka.

Material and methods

As many as 30881 surface soil samples (0-20 cm) were collected from 910 tank command areas covering 46 talukas of 10 districts belonging to five agro-climatic zones. Because only two talukas of Zone 2 were represented, Zone 2 (north eastern dry zone) and Zone 3 (northern dry zone) were combined as one due to climatic similarity. Micronutrients were determined from a limited sample size of five per tank from 630 tanks. The particulars of samples drawn agro-climatic zone wise and taluka wise is given in Table 1. The samples were analyzed by following standard analytical procedures. The pH was determined in 1:2.5 soil: water suspension, electrical conductivity in 1:2.5 soil-water extract, organic carbon by Walkey and Black's wet oxidation method, available phosphorous was extracted either using Bray or Olsen extractant depending on the soil pH and the extracted P was determined using a spectrophotometer; available potassium was extracted using N NH_4OAc and subsequent estimation of K was done using flame photometer (Jackson, 1973). DTPA extractable zinc and iron were determined using atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

The soil fertility map was prepared indicating the predominant fertility class of the taluka based on per cent samples under different fertility classes.

Results and discussion

Soil pH varied widely depending on the area (Fig. 1). Among the four agro-climatic zones, a distinct trend in soil pH was observed. The mean pH of soils of transitional zone (Zone 1 and Zone 8) was neutral with mean value of 7.22 and 6.93, respectively (Table 1). Nearly half of the soil samples recorded neutral pH in these two zones (Table 2). Between the transitional zones (Zone 1 and Zone 8), soil acidity was more common in Zone 8, than Zone 1 as borne out by the fact that proportion of soils with acidic pH was 27 percent in the former against 15 per cent in the latter. Concomitantly, the soils with alkaline pH constituted 36 per cent in Zone 1 and 22 per cent in Zone 8. Acidic soils dominated Zone 9 (56%) with a mean pH of 6.39, which is related to the intense leaching regime as induced by higher rainfall in the zone. However, considerable samples (37%) exhibited neutral pH in Zone 9 especially in Hanagal, Halyal and Kalghatagi which have a milder leaching regime compared

Table 1. Fertility status of tank command areas in different zones of North Karnataka

Taluk	No. of tanks	No. of samples	pH	EC (dS m^{-1})	OC (%)	Av. P_2O_5 (Kg ha^{-1})	Av. K_2O (Kg ha^{-1})	DTPA extractable Zn (mg kg^{-1})	DTPA extractable Fe (mg kg^{-1})
I. Zone-1 (North-Eastern transitional zone)									
Aurad	13	592	7.38	0.38	0.60	25.2	325	0.31	4.16
B. Kalyana	11	337	7.16	0.23	0.61	22.8	281	0.40	4.55
Bhalki	2	76	7.17	0.17	0.55	22.1	256	0.49	5.33
Bidar	15	440	7.21	0.31	0.62	13.3	282	NA	NA
Humanabad	12	371	7.07	0.37	0.60	15.4	285	NA	NA
Mean (Total)	(53)	(1816)	7.22	0.32	0.61	19.7	295	0.36	4.38
	Range		7.07-7.38	0.17-0.38	0.55-0.62	13.3-25.2	256-325	0.31-0.49	4.16-5.33
	Std Dev.		0.11	0.09	0.03	5.13	24.81	0.23	2.60
	CV (%)		1.57	27.89	4.64	26.00	8.40	64.19	59.32
II. Zone-2 and 3 (North-Eastern dry zone and Northern dry zone)									
Raichur	69	2811	8.18	0.32	0.43	18.8	241	NA	NA
Manvi	2	64	8.52	0.53	0.53	24.1	485	0.63	8.91
Gangavati	7	178	8.08	0.32	0.47	22.6	287	NA	NA
Koppal	7	207	7.68	0.31	0.43	25.0	320	NA	NA
Kustagi	2	76	7.50	0.67	0.29	13.8	207	NA	NA
Yalaburga	4	118	7.66	0.26	0.35	15.9	257	NA	NA
Bilagi	6	197	7.53	0.27	0.49	24.7	273	0.71	5.65
Jamakhandi	7	207	7.92	0.39	0.59	17.5	240	0.35	4.90
Mudhol	5	240	7.91	0.37	0.59	21.7	251	0.49	5.43
Badami	17	668	7.65	0.56	0.41	25.6	239	0.43	3.63
Hunagund	10	444	7.66	0.42	0.42	15.4	216	NA	NA
Bagalakot	4	248	7.80	0.41	0.56	19.0	238	NA	NA
Lingasagur	11	295	8.12	0.28	0.54	64.5	323	NA	NA
B.bagewadi	11	337	7.51	0.39	0.50	26.1	385	1.08	5.72
Bijapur	15	464	8.17	0.42	0.56	29.0	352	1.06	5.56
Indi	8	303	7.65	0.44	0.58	25.1	309	0.59	6.38
Muddebihal	13	378	7.70	0.41	0.55	24.0	390	0.93	6.74
Ramadurga	8	233	8.20	0.32	0.49	39.0	249	0.23	2.36
Athani	5	155	8.07	0.64	0.40	39.6	350	0.59	3.82
H. B. Halli	10	409	7.83	0.38	0.46	21.9	311	NA	NA
Hadagali	8	278	8.11	0.45	0.38	17.8	258	NA	NA
Hosapete	9	308	7.79	0.47	0.46	18.5	268	NA	NA
Kudligi	22	793	7.85	0.39	0.52	17.8	259	NA	NA
Mean (Total)	(260)	(9411)	7.94	0.39	0.47	22.9	274	0.67	5.10
	Range		7.50-8.52	0.26-0.67	0.29-0.59	13.8-64.5	207-485	0.23-1.08	2.36-8.91
	Std Dev.		0.27	0.11	0.08	10.85	66.24	0.38	2.99
	CV (%)		3.36	27.99	16.96	47.38	24.18	56.22	58.52
III. Zone-8 (Northern transitional zone)									
Dharwad	39	1041	6.64	0.40	0.63	29.3	397	0.58	5.15
Hubli	12	292	7.11	0.48	0.52	27.4	352	0.89	10.58
Byadagi	35	1041	6.93	0.37	0.52	29.8	388	0.64	10.88
Shiggaon	50	1349	6.58	0.42	0.62	28.0	355	0.61	9.60
Hirekerur	77	2101	6.97	0.42	0.54	30.2	370	0.73	13.75
Haveri	6	135	7.16	0.35	0.55	34.1	417	0.58	10.05
Ranebennur	2	40	8.20	0.37	0.53	31.6	451	1.16	7.57
Savanur	7	261	7.66	0.32	0.51	33.5	416	0.94	9.44
Bailhongal	33	1073	7.06	0.32	0.64	33.6	365	0.55	10.96
Belgaum	21	711	6.72	0.41	0.69	33.6	373	0.92	17.07
Chikkodi	8	276	7.62	0.56	0.62	34.1	423	0.69	5.75
Hukkeri	11	366	7.39	0.42	0.63	33.0	363	0.56	9.37
Mean (Total)	(301)	(8686)	6.93	0.40	0.59	30.7	376	0.68	10.90
	Range		6.58-8.20	0.32-0.56	0.51-0.69	27.4-34.1	352-451	0.55-1.16	5.15-17.07
	Std Dev.		0.48	0.07	0.06	2.46	31.71	0.19	3.23
	CV (%)		6.89	16.71	10.27	8.02	8.43	28.59	29.60
IV. Zone-9 (Hilly zone)									
Kalaghatagi	56	1601	6.66	0.41	0.54	28.3	401	0.81	15.19
Haliyal	24	764	6.06	0.34	0.74	29.2	255	0.80	17.91
Mundagod	35	915	5.89	0.24	0.73	29.2	211	0.92	20.20
Sirsi	33	826	5.92	0.33	0.56	23.8	223	0.71	16.57
Hanagal	101	5398	6.56	0.32	0.57	15.9	240	1.15	19.87
Khanapur	47	1464	6.23	0.31	0.56	29.1	301	0.75	20.17
Mean (Total)	(296)	(10968)	6.39	0.33	0.59	22.1	269	0.97	18.87
	Range		5.89-6.66	0.24-0.41	0.54-0.74	15.9-29.2	211-401	0.71-1.15	15.19 -20.2
	Std Dev.		0.33	0.06	0.09	5.32	70.48	0.16	2.12
	CV (%)		5.13	16.80	15.51	24.08	26.23	16.42	11.21

*NA- Not analysed

to Sirsi and Khanapur which receive much higher rainfall as observed earlier by Patil and Dasog (1997).

Alkaline pH marked the soils of Zone 2 & 3 with an average pH of 7.94. About 75 per cent samples were alkaline and 23 per cent were neutral. This is directly related to lower rainfall in this zone, resulting in accumulation of bases. The soils with neutral pH were mostly confined to red soils associated with black soils, a situation common to this zone (Rudramurthy and Dasog, 2001).

Average electrical conductivity values recorded were low (1:2.5 soil-water ratio) in soils of all the zones and varied narrowly from 0.32 to 0.40 dS m^{-1}. This is due to averaging effect of a number of normal soils with few saline soils as in a low intensity sampling. The picture is clear if one looks at the per cent samples that are saline. As high as 23 per cent samples were saline in Zone 2 & 3 compared 4 per cent in Zone-8 and still less in other zones (Table 2). This is expected as this zone is dry compared to other zones. The variability of electrical conductivity values in Zone 1 and Zones 2 & 3 soils is relatively higher compared to that in soils of Zone 8 and Zone 9.

Mean organic carbon ranged from low in Zone 2 & 3 to medium in other three zones (Table 1) and the same is evident in Fig 2. The picture was clearer when looked at the proportion of soils falling under the three categories of organic carbon (Table 2). Low organic carbon soils comprised 57 per cent of soils and medium in 30 per cent soils in Zone 2 & 3. Soils with medium organic carbon content dominated in Zone 1 and Zone 8 (transitional zones). The proportion of samples under high category was 13 per cent in Zone 2 & 3 and ranged from 18 to 23 per cent in other three zones. This may be due to the prevalence of high temperature causing the organic matter to oxidize and deplete at a faster in semi-arid region. This, coupled with low vegetation cover, has resulted in less accumulation of organic matter in the soil. The organic matter build up in soils is related to rainfall, temperature and natural vegetation (Bhattacharyya *et al.,* 2000). However, low variability (CV of 4.64%) was observed in its content in Zone 1 with somewhat higher variability in Zone 2 & 3 and Zone 8.

The mean available phosphorus (Table 1) ranged from 19.7 kg P_2O_5 ha^{-1} in Zone 1 to 30.7 kg P_2O_5 ha^{-1} in Zone 8. The variation in available phosphorus was highest in Zone 2 & 3 (47.38%), and it was least in Zone 8 (8.02%) and intermediate in Zone 1 and Zone 9 (26% and 28.08%, respectively). The high levels of available phosphorus in soils of Zone 8 is ascribed mainly due to neutral soil pH. Sixty five per cent of the soils contained medium phosphorus, followed by low category in 30 per cent of the samples (Table 2). With respect to Zones 1, 8 and 9, the low available phosphorus category dominated the medium class irrespective of wide variation in the agro-climatic conditions (Fig. 3). Soils high in P_2O_5 did not exceed 5 per cent in Zone 8. The dominance of low category is ascribed predominantly to acidic pH in Zone 9 coupled with preponderance of sesquioxides, and due to alkaline pH and calcareousness in Zones 1, 2 and 3 (Murthy, 1988).

The mean available potassium content varied from 269 kg K_2O ha^{-1} in Zone 9 soils to 376 K_2O ha^{-1} in Zone 8 soils (Table 1) was high in soils of all zones. Although judged by the mean available potassium content, all zones recorded high in potassium, the picture is clearer when we sort the samples in different categories (Table 2).

In sharp contrast to available phosphorus, soils with low potassium status constitute just 3-8 per cent in zone 1, 2 & 3, and 8 with Zone 9 having 13 per cent soils under low category. Zone 8 stands out with 72 per cent of soils having high status of available K_2O, while in other 3 zones 32-36 per cent of the soils analyzed are high. In Zone 1, 2 & 3, and 9 soils are predominantly medium in available K_2O. The high available potassium in Zone 8 is probably related to Dharwad schist formation, which is rich in micaceous minerals (Radhakrishna and Vaidyanathan, 1997). Finck and Venkateshwarlu (1982) observed that many Vertisols are able to maintain a sufficient pool of exchangeable potassium to provide a good supply of potassium to plants for many years. The variability in available K_2O was highest in Zone 9 (26.23%) and, also in the soils of Zone 2 & 3 (24.18%); the variability in Zone 1 and 8 was considerably less (8.4% and 8.43%, respectively).

All talukas of Zone 1 and Zone 2 & 3 were found medium in available potassium content except Manvi, Basavana Bagewadi, Vijayapur, Muddebihal and Athani were in high range (Fig. 4). Sixty one per cent of samples in these zones were found medium and 32 per cent were high and 3 per cent were low. Whereas, soils of all talukas of Zone 8 were found high in available potassium content with 72 per cent samples being high in available potassium. Compared to other zones, soils of Zone 9 were relatively low in potassium content due to more leaching of bases and kaolinite clay having lower exchangeable sites (Ningappa and Vasuki, 1989).

Fifty per cent of soils in Zone 1 were sufficient in iron with remaining being deficient. However, soils of all other zones exhibited sufficiency. Comparatively soils in Zone 9 contained higher amount of iron than other zones (Fig. 5). This could be due to presence of iron oxides in the soils of Zone 9. Low iron content in other zones may be due to precipitation of iron by $CaCO_3$, resulting in reduced Fe availability.

Table 2. Percent soil samples falling under different fertility classes in different agro-climatic zones of North Karnataka

Zones	pH			EC (dS/m)		OC			Available P_2O_5			Available K_2O			DTPA ext. Zn		DTPA ext. Fe	
	A	N	Al	S	NS	L	M	H	L	M	H	L	M	H	S	D	S	D
Zone-1	15	49	36	1	99	33	46	21	77	23	1	3	61	36	19	81	50	50
Zone-2 and 3	2	23	75	23	77	57	30	13	69	28	3	8	61	32	47	53	90	10
Zone-8	27	51	22	4	96	32	50	18	30	65	5	3	25	72	47	53	98	2
Zone-9	56	37	7	2	98	40	37	23	64	36	1	13	53	35	80	20	100	0

*A- Acidic, N-Neutral, Al- Alkaline, S- Saline, NS- Non-saline, L- Low, M- Medium, H- High, S- Sufficient, D- Deficient

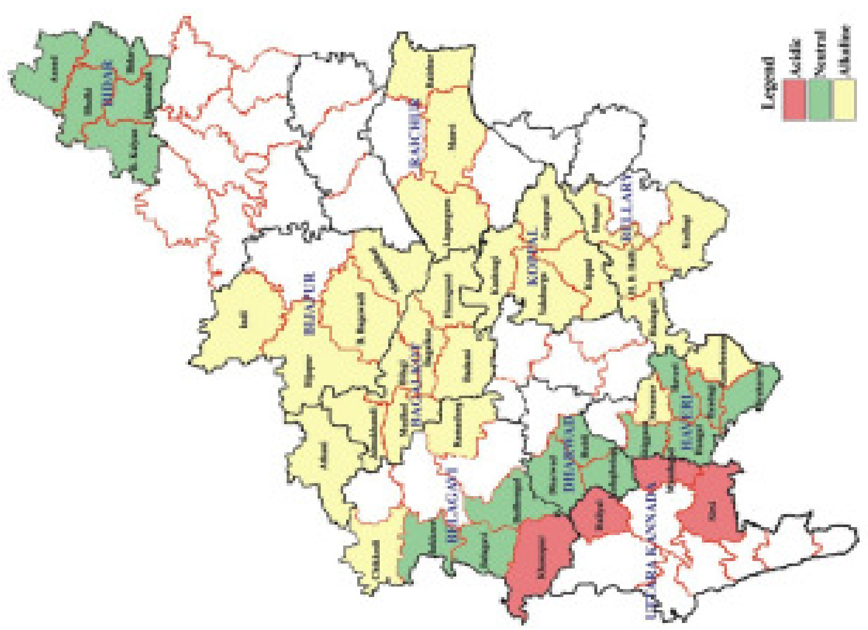

Fig. 1. Status of soil pH

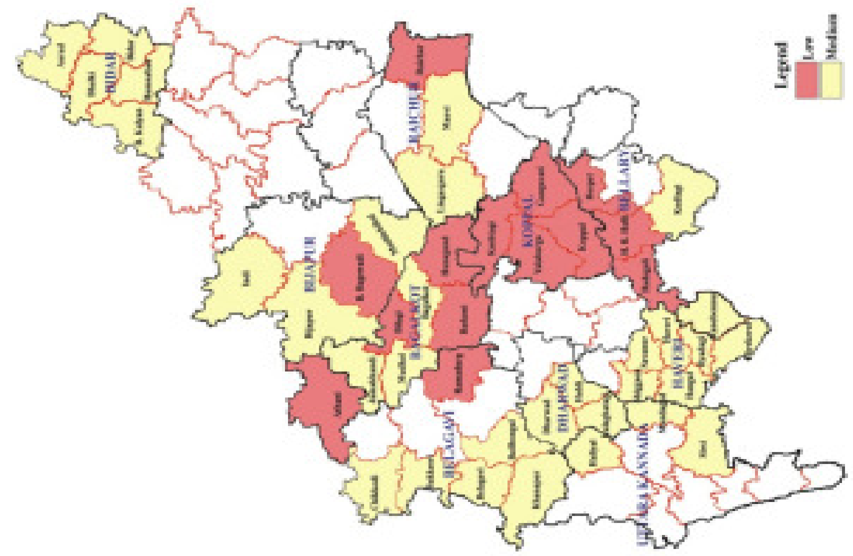

Fig. 2. Status of organic carbon

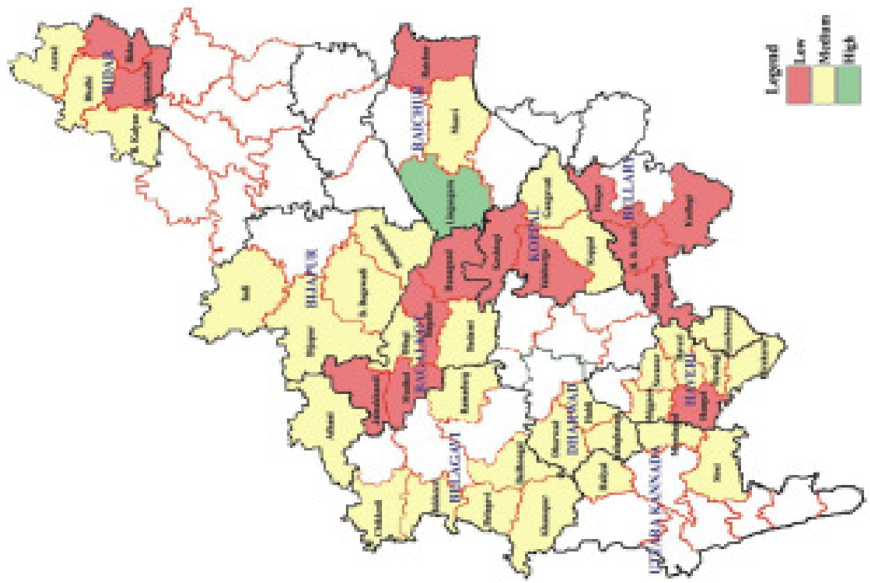

Fig. 3. Status of available phosphorus

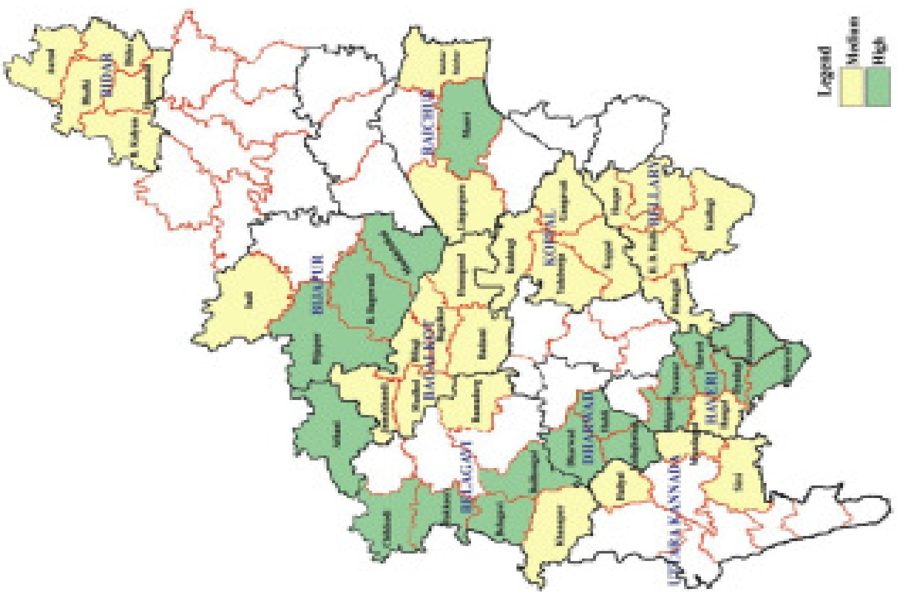

Fig. 4. Status of available potassium

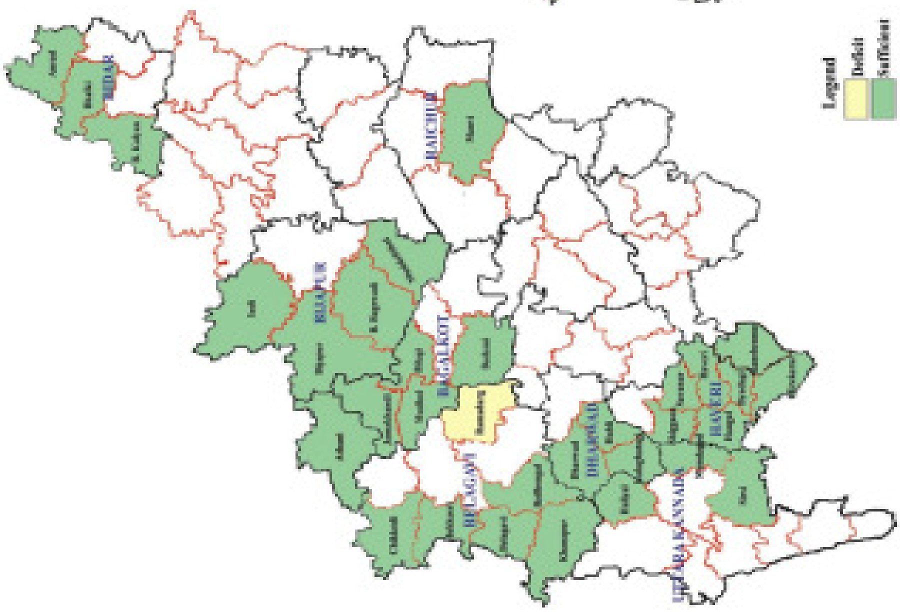

Fig. 5. Status of available iron

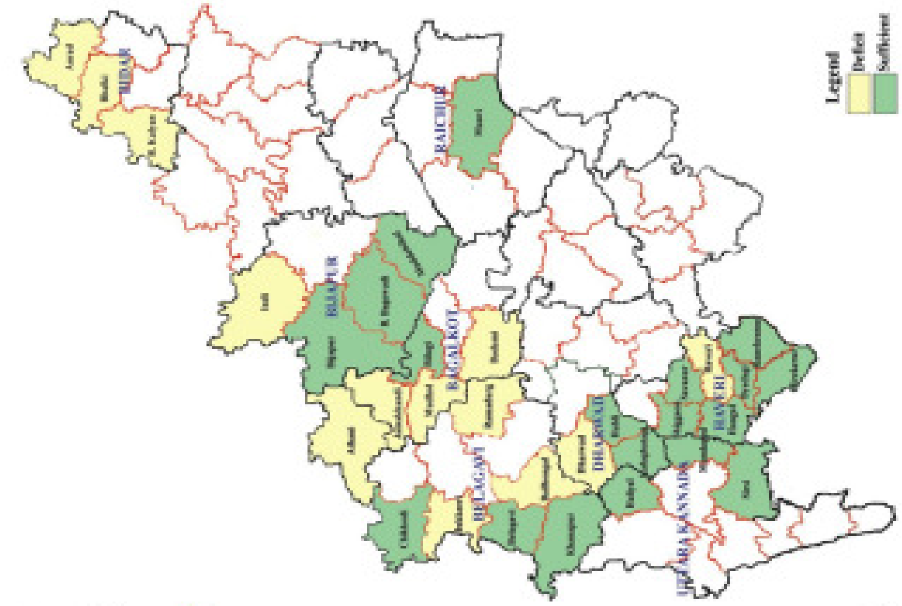

Fig. 6. Status of available zinc

Zinc was distinctly deficient in Zone 1 as 81 per cent of the samples were below the critical limit. Contrastingly, only 20 per cent of the soils in Zone 9 were deficient in zinc. This could be primarily ascribed to acidic pH of these soils. Soils of dry zone (Zones 2 & 3) and northern transitional zone (Zone 8) were deficient in zinc to the extent of 53 per cent. Zinc availability was sufficient in most of the talukas in the study area. But the deficiency of zinc was observed in some talukas (Fig. 6). Among the zones, Zone 8, 2 and 3 were found marginally sufficient (0.68 and 0.67 mg kg^{-1}, respectively) with respect to available zinc and the soils of Zones 9 (0.97 mg kg^{-1}) were sufficient, whereas soils of Zone 1 were deficient (0.36 mg kg^{-1}). The variation in content of Zn and Fe within a zone is high in Zone 1 and Zone 2 & 3 as compared to Zone 8 and Zone 9.

The study gives a broad insight into the health of soils on a regional scale and is not applicable to site-specific nutrient management. Such studies, if done periodically, will give the trends of soil fertility management on a regional scale and corrective measures, if any, to be taken.

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