Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(2): 1220-1226
Received: 03-01-2019
Accepted: 07-02-2019

Ranjitha P
Senior research fellow
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navile, Shivamogga, Karnataka, India

Chidanandappa HM
Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navile, Shivamogga, Karnataka, India

Dhananjaya BC
Assistant Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navile, Shivamogga, Karnataka, India

Prashanth KM
Research Associate, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navile, Shivamogga, Karnataka, India

Correspondence
Ranjitha P
Senior research fellow
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Navile, Shivamogga, Karnataka, India

Chemical properties and available zinc status in soils coming under paddy land use cover of Bhadra command, Karnataka

Ranjitha P, Chidanandappa HM, Dhananjaya BC and Prashanth KM

Abstract
A study was conducted to assess the available zinc status in soils under paddy land use cover of Bhadra command, Karnataka. One hundred and forty-five soil samples were collected from seven different taluks coming under paddy land use cover of Bhadra command and analyzed for physical and chemical properties and available zinc status. Considering 0.60 mg kg-1 as the critical limit of DTPA zinc in soils, 70.34 and 29.66 per cent samples were found to be sufficient and deficient in available zinc, respectively. Sufficiency in available zinc status attributed to regular addition of ZnSO4 to soils for every season of paddy. Further, it is also influenced by pH, organic carbon and CaCO3 content of the soils.

Keywords: Available zinc status, land and chemical properties

Introduction
Introduction of high yielding varieties of crops and the concomitant usage of high doses of chemical fertilizers without or less organic manures over a period of time not only boosted crop yields but also caused for depletion of the native available micronutrients status of soils and their concentration in plant tissue in addition to decreasing in yield potential of soils. Among the micronutrients, zinc and boron nutrient elements appeared to be more deficient in soils. Available zinc content in the surface layer of soils of India ranged from 0.08 to 20.5 mg kg-1 and about 48 per cent of Indian soils are deficient in zinc (Takkar, 1996) [19]. Further, it has been reported that 78 per cent of the soils in Karnataka were found to be deficient in zinc (Singh and Saha, 1995) [18]. This indicates that zinc deficiency appeared to be one of the most important limiting factors for crop production in Karnataka (Shivaprasad *et al*., 1996) [11]. Zinc deficiency in human is a serious threat not only to the health of individuals but also to the economy of developing nations.

Even though zinc requirement of plants is very small, it plays a greater role in plant metabolism. Zinc is a component of superoxide dismutase, alcohol dehydrogenase and carbonic anhydrase enzymes. It is required for synthesis of IAA or auxin growth regulator and also involved in protein and carbohydrates metabolism. Zinc also plays a key role in stabilizing RNA and DNA structure, in maintaining the activity of DNA synthesizing enzymes and controlling the activity of RNA degrading enzymes. But, the concentration of zinc in plants is a function of its availability in soils and the main factors affecting zinc availability in soils are pH, organic matter content, $CaCO_3$ and clay contents of soils.

Bhadra command comes under Southern Transition Zone of Karnataka. The command area of Bhadra reservoir is spread across an area of 1.2 lakh ha in the districts of Shivamogga, Chikkamagaluru and Davanagere. The Bhadra Dam drains a catchment area of 1,968 square kilometres. Out of which the forest area is 717.49 ha, cultivable land is 3,274.65 ha and fallow land is 7,258.74 ha. The Bhadra River basin receives an average annual rainfall of 2320 mm. Paddy (*Oryza sativa* L.), coconut (*Cocos nucifera* L.) and areca nut (Areca catechu L.) are the crops mainly grown in these areas and application of ZnSO4 is a common practice for each season of paddy even though it is recommended once in three seasons. There is no systematic information available in respect of zinc status of soils under paddy land use cover of Bhadra command and also it is very much essential for management of zinc nutrition in paddy.

2. Material and methods
A laboratory experiment was conducted at University of Agricultural and Horticultural Sciences, Shivamogga to know the available zinc status in surface soils coming under paddy land use cover of Bhadra command, Karnataka. For the present study, 145 surface soil samples (0-15 cm depth) were collected from soils under paddy cultivation of different villages of

seven taluks coming under Bhadra command namely Shivamogga, Bhadravathi, Tarikere, Channagiri, Honnali, Harihara and Davanagere (Fig. 1). The collected soil samples were brought to the laboratory, dried under shade, powdered by using wooden pestle and mortar and passed through 2 mm sieve. The 2 mm sieved air dried samples were stored in polythene bags and analysed for physical and chemical properties and available zinc status using standard procedures. The available zinc in soil was extracted with DTPA-extractant (0.005 M diethylene tri aminepenta acetic acid+ 0.01 M $CaCl_2$ + 0.1 M triethanolamine) at 1:2 soil to extractant ratio as described by Lindsay and Norvell (1978) [9]. The concentration of zinc in the extract was determined by atomic absorption spectrophotometer (AAS) under suitable measuring conditions (Page *et al*., 1982) [11].

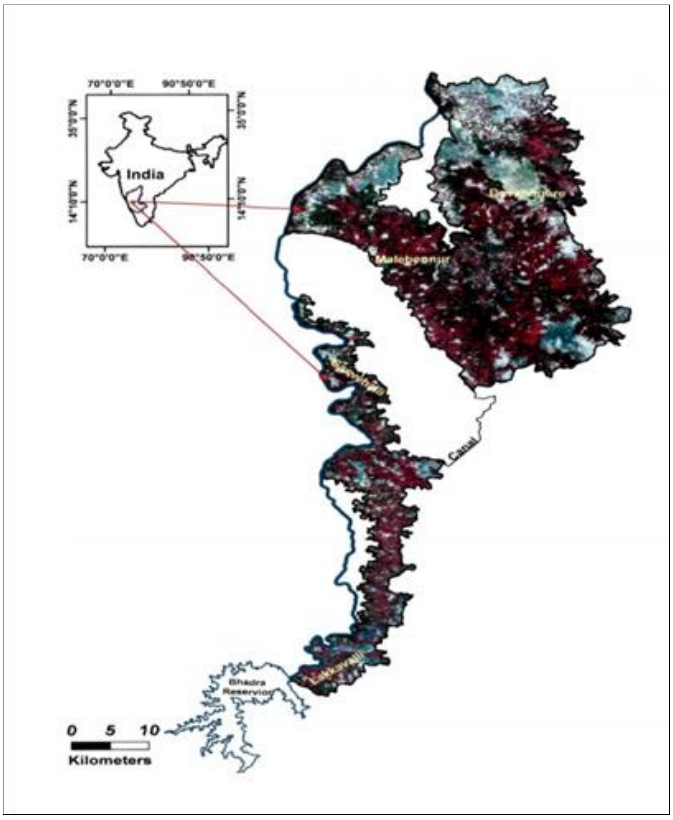

Fig 1: Map of Bhadra command in Karnataka

3. Results and Discussion

3.1 Soil pH

The soils coming under paddy cover in Bhadra command of Karnataka recorded pH in the range of 5.02 to 8.63 (Table 1). Further, out of 145 soil samples collected from seven taluks of Bhadra command, 57 (39.31%) soil samples recorded acidic pH (<6.5), 50 samples (34.48%) recorded normal pH (6.5-7.5) and 39 (26.90%) samples recorded higher pH (>7.5). Among taluks, the majority of samples under Shivamogga, Bhadravathi, and Tarikere taluks recorded acidic pH while samples under Channagiri, Honnali, Harihara and Davanagere taluks showed normal to alkaline pH. Acidic nature of these soils might be due tothe intensity of weathering coupled with intensive leaching of bases due to heavy rainfall and acidic parent material from which these soils are formed and higher accumulation of iron and aluminium oxides in soils (Ananthanarayana and Perur, 1973). Whereas, Alkaline pH in soils might be due to the use of basic fertilizers which might lead to the increase in pH of some fields and also might be due to the accumulation of bases as a result of restricted drainage. Meena *et al*. (2006) [10] reported that, the high pH of soils also might be due to the presence of high degree of base saturation. The complexing of exchangeable and free Al^{3+} ions by aliphatic and aromatic hydroxy acids, humates and lignins produced during decomposition and at the same time release of basic cations from these materials (Deka and Poonia, 1977 and Grewal *et al*., 1981) [5, 7].

3.2 Electrical conductivity

Out of 145 soil samples collected from seven different taluks of Bhadra command, 140 (96.55%) samples recorded the EC < 1.00dSm-1 at 25oC which is considered to be normal and only 5 (3.45%) samples from Davanagere taluk recorded EC >1.00 dSm-1 at 25oC (i.e., in the range of 1.06 to 1.20 dSm-1 at 25oC) (Tables 1). The variation in soluble salts in soils might be attributed to the variation in the degree of leaching of salts from soils due to high rainfall and high salts due to restricted drainage. Similar results were reported in red sandy soils of Garikapadu of Andhra Pradesh, where normal EC values attributed to low soluble salts Rajeswar *et al*. (2009) [12] and Jyoti and Sureshbhai (2012) [1]. Binita *et al*. (2009) also reported the normal EC value in the Ghataprabha left bank canal command area by using GIS technique.

3.3 Organic Carbon

Organic carbon status of the soils are given in Tables 1 which indicated that, 25 samples (17.24%), 37 samples (25.52%) and 83 samples (57.24%) were recorded low (<5g kg-1), medium (5-7.5g kg-1) and high (>7.5g kg-1) organic carbon status respectively. The variation in organic carbon status might be attributed to management practices with or without the addition of organic manure and also acidic nature of these soils. Binita *et al*. (2009) [2] reported that the Indian soils that are formed under sub-humid climate where the organic carbon content ranged from low to medium. The higher amounts ofsoil organic carbon in soils could be due to in situ incorporation of rice stubbles and straw through the process of mechanization and addition of organic manures. Similar results were also reported by Selvaraj *et al*. (2012) [2] and Chidanandappa (2003) [2] who reported that addition of organic manure enhanced the organic carbon content in soils.

3.4 Calcium carbonate equivalent

The $CaCO_3$ equivalent values were in the range of 0.35 and 5.89 per cent with a mean value of 3.12 per cent (Table 1). Lowest was found in Shivamogga taluk whereas highest was found in Davanagere taluk. Low calcium carbonate equivalent per cent might be due to acidic pH of soils where bases were leached down due to heavy rainfall (Selvaraj *et al*., 2012) [2].

3.5 Available Zinc

Available zinc status in Shivamogga, Bhadravathi, Tarikere, Chennagiri, Honnali, Harihara and Davanagere taluks ranged from 0.47 to 0.83, 0.44 to 1.38, 0.38 to 1.98, 0.55 to 1.98, 0.10 to 0.82, 0.41 to 2.30 and 1.05 to 2.41 mg kg-1 with a mean value of 0.72, 0.87, 1.06, 0.94, 0.36, 1.28 and 1.61 mg kg-1 respectively. Low available zincstatus was noticed in Honnali taluk whereas high was noticed in soils of Davanagere taluk (Table 1). Low available zinc status in soils might be due to intensive cultivation coupled with high pH. Brady and Weil (2002) [3] reported that, as soil pH increased, the ionic forms of these micronutrient cations are changed first to the hydroxyl ions and finally to the insoluble hydroxides and availability decreases. Similar results were also reported by Ravikumar *et al*. (2007) [14] in Malaprabha right bank command area. The soils recorded more zinc probably due to the regular addition of zincin the form of ZnSO4 to the paddy soils for each season under Bhoochethana programme. However Duraisamy *et al*. (1988) [6] and Rama and Prakash, 2014 reported similar results, i.e., application of zinc (10–20 mg kg-1 soils) to rice crop improved the availability of zinc in soils. Further, it could also due to the presence of high organic carbon as organic matter improves soil aeration and protects the oxidation and precipitation of nutrients into unavailable form and supply chelating agents which increase the solubility of micronutrient content as reported by Jyoti and Sureshbhai (2012) [8]. Sharma *et al*. (2003) [7] reported that the higher values might be due to the higher content of organic carbon as well as the finer fraction of soils leading to increasing in the surface area for ion exchange and hence contributed to the higher amount of DTPA- Zn in the soil.

Considering the critical limit of DTPA extractable zinc (0.60 mg kg-1) in soils, in Shivamogga taluk, 11 and two samples out of 13 samples were found to be sufficient and deficient in available zinc status contributing 84.62 and 15.38 per cent respectively. Whereas, in Bhadravathi taluk 17 and seven samples out of 24 samples were found to be sufficient and deficient contributing 70.83 and 29.17 per cent respectively. Similarly in Tarikere taluk, out of 20 samples, 15 and fivesamples were found to be sufficient and deficient constituting 75 and 25per cent respectively. Further in Channagiri taluk, out of 25 samples, 23 samples were sufficient and two samples were deficient concerning available zinc status contributing 92.00 and 8.00 per cent respectively. Out of 25 samples in Honnali taluk, only three samples were found to be sufficient and 22 samples were found to be deficient constituting 12.00 and 88.00 per cent respectively. In case of Harihara taluk, 18 and five samples out of 23 samples were found to be sufficient and deficient in available zinc status contributing 78.26 and 21.74 per cent respectively. Further, in Davanagere taluk, all 15 samples were found to be sufficient in available zinc status constituting 100.00 per cent (Fig 2). Out of 145 samples, 102 samples (70.34%) were found to be sufficient whereas 43 samples (29.66%) were found to be deficient in DTPA zinc (Fig. 3).

Table 1: Chemical properties and available zinc status in surface layer (0-15 cm) of soils under paddy cover in different taluks of Bhadra command, Karnataka

Shivamogga Taluk					
Sample No.	**pH**	**EC (1:2, dSm^{-1} at 25 ^{0}C)**	**OC (g kg^{-1})**	**Calcium carbonate equivalent (%)**	**Zinc (mg kg^{-1})**
1	5.09	0.56	3.88	0.53	0.69
2	5.12	0.51	7.50	0.43	0.50
3	5.02	0.59	7.76	0.41	0.47
4	5.13	0.68	4.50	0.47	0.74
5	5.16	0.62	4.23	0.41	0.83
6	5.06	0.57	4.50	0.50	0.70
7	5.24	0.72	3.54	0.85	0.80
8	5.20	0.75	6.30	0.40	0.73
9	5.13	0.58	4.26	0.68	0.78
10	5.19	0.54	6.00	0.40	0.79
11	5.28	0.57	6.64	0.71	0.71
12	5.16	0.53	5.40	0.35	0.76
13	5.14	0.66	4.53	0.53	0.80
Range	5.02-5.28	0.51-0.75	3.54-7.76	0.35-0.85	0.47-0.83
Mean	5.15	0.61	5.31	0.52	0.72
Bhadravathi Taluk					
1	5.46	0.47	6.32	0.63	0.57
2	5.75	0.69	5.40	0.59	0.55
3	5.53	0.57	4.52	0.71	0.45
4	5.69	0.69	3.90	0.81	0.44
5	5.72	0.78	4.81	0.71	0.54
6	7.03	0.76	4.20	1.25	1.38
7	5.67	0.54	4.20	0.71	0.88
8	5.56	0.63	4.56	0.66	0.83
9	6.79	0.59	5.40	1.15	1.05
10	5.40	0.78	4.50	0.51	0.87
11	5.46	0.81	7.26	0.56	0.86
12	5.38	0.54	6.32	0.63	1.16
13	5.13	0.67	5.70	0.63	0.82
14	5.11	0.64	7.77	0.56	0.84
15	5.30	0.58	6.04	0.78	1.12
16	5.48	0.69	6.00	0.51	0.67
17	5.23	0.59	6.88	0.84	0.59
8	5.37	0.61	7.50	0.56	0.56
19	5.41	0.63	5.12	0.51	1.22
20	5.47	0.66	7.20	0.59	1.35
21	5.36	0.61	7.82	0.66	1.23
22	5.46	0.69	6.90	0.51	1.32

23	5.12	0.76	4.50	0.74	0.80
24	5.04	0.71	6.03	0.51	0.70
Range	5.04-7.03	0.47-0.81	3.90-7.82	0.51-1.25	0.44-1.38
Mean	5.54	0.65	5.79	0.70	0.87
Tarikere Taluk					
1	5.54	0.66	6.88	0.84	1.04
2	5.40	0.69	6.00	0.84	1.15
3	5.07	0.71	4.22	0.68	0.41
4	5.02	0.76	4.80	0.63	0.38
5	5.09	0.67	5.13	0.71	0.73
6	5.04	0.66	4.20	0.59	0.82
7	5.38	0.62	4.50	0.68	1.04
8	5.25	0.65	6.60	0.87	1.09
9	5.94	0.89	5.65	0.84	1.98
10	5.91	0.83	4.20	1.00	1.56
11	5.82	0.67	4.80	0.66	1.93
12	5.54	0.75	5.70	0.63	0.59
13	5.47	0.64	4.86	0.76	1.82
14	5.56	0.67	4.50	0.92	1.78
15	5.60	0.54	3.89	0.84	1.63
16	5.36	0.48	5.67	1.08	0.49
17	5.49	0.43	5.40	0.63	0.81
18	5.45	0.58	6.00	0.76	0.67
19	5.56	0.56	5.70	0.71	0.54
20	5.67	0.67	4.76	0.95	0.82
Range	5.02-5.94	0.43-0.89	3.89-6.88	0.59-1.08	0.38-1.98
Mean	5.46	0.66	5.17	0.78	1.06
Channagiri Taluk					
1	7.12	0.83	9.88	2.95	0.98
2	6.75	0.67	8.12	2.73	0.98
3	7.07	0.69	11.69	3.07	1.98
4	6.99	0.65	8.42	2.57	1.14
5	7.16	0.73	9.32	2.02	1.44
6	7.19	0.76	8.43	2.23	1.18
7	7.06	0.83	7.53	2.48	1.08
8	7.06	0.74	8.98	2.48	1.45
9	6.98	0.73	10.78	2.95	1.02
10	6.84	0.69	8.12	2.48	1.16
11	6.70	0.73	10.78	3.19	1.02
12	7.19	0.71	13.20	3.26	1.06
13	7.33	0.78	7.69	2.88	0.65
14	7.49	0.83	12.56	2.57	0.71
15	7.67	0.86	11.16	2.64	0.75
16	7.56	0.79	11.94	2.73	0.66
17	7.96	0.84	11.09	3.35	0.79
18	7.24	0.79	12.88	3.10	0.84
19	7.49	0.78	8.67	4.50	0.73
20	7.85	0.71	10.79	4.12	0.68
21	7.31	0.75	9.26	2.88	0.68
22	7.65	0.85	9.88	2.57	0.64
23	7.40	0.94	10.48	2.88	0.66
24	7.38	0.86	8.13	2.95	0.55
25	7.46	0.79	9.36	2.95	0.58
Range	6.70-7.96	0.65-0.94	7.53-13.2	2.02-4.50	0.55-1.98
Mean	7.28	0.77	9.97	2.93	0.94
Honnali Taluk					
1	8.22	0.84	9.02	4.50	0.63
2	8.37	0.97	9.29	3.57	0.41
3	8.35	0.92	11.69	5.21	0.32
4	8.63	0.86	12.56	2.33	0.80
5	7.76	0.77	9.06	2.17	0.34
6	8.42	0.93	9.67	2.79	0.19
7	7.66	0.82	11.12	2.42	0.20
8	7.82	0.79	6.89	3.50	0.26
9	7.89	0.74	8.12	2.64	0.50
10	8.34	0.76	9.32	2.33	0.47
11	7.87	0.90	9.89	2.64	0.13
12	7.90	0.92	9.36	2.73	0.51

13	7.93	0.83	11.16	2.33	0.10
14	7.79	0.85	10.47	4.28	0.32
15	7.93	0.74	10.77	4.74	0.22
16	8.19	0.86	7.64	4.50	0.16
17	8.20	0.95	9.89	4.90	0.46
18	7.46	0.89	11.09	4.65	0.38
19	7.23	0.83	7.45	5.74	0.36
20	7.43	0.86	8.56	3.66	0.48
21	7.79	0.77	9.88	4.28	0.82
22	7.45	0.79	8.07	3.19	0.20
23	7.80	0.83	9.02	3.35	0.32
24	7.36	0.86	9.59	3.72	0.24
25	7.10	0.87	7.76	3.19	0.22
Range	7.10-8.63	0.74-0.97	6.89-12.56	2.17-5.74	0.10-0.82
Mean	7.88	0.85	9.49	3.60	0.36
Harihara Taluk					
1	7.72	0.79	7.17	2.18	0.78
2	7.22	0.81	8.70	2.52	1.52
3	7.26	0.94	9.00	2.88	1.90
4	7.28	0.82	12.28	2.74	2.30
5	7.30	0.86	10.20	3.16	1.93
6	7.01	0.83	12.56	3.16	2.27
7	7.15	0.75	11.40	3.22	1.79
8	7.18	0.71	12.00	3.30	2.01
9	7.32	0.82	12.58	3.16	2.13
10	7.47	0.87	11.67	3.08	2.15
11	7.01	0.78	9.00	2.32	0.53
12	7.18	0.91	7.50	2.52	0.41
13	7.63	0.65	7.80	2.38	0.56
14	7.12	0.88	11.40	2.88	2.06
15	7.20	0.95	10.48	2.74	0.58
16	7.04	0.69	9.30	2.94	0.59
17	7.21	0.88	6.87	2.52	0.66
18	7.57	0.98	8.10	2.46	0.64
19	7.07	0.86	10.78	2.38	0.99
20	7.28	0.82	9.00	2.88	0.65
21	7.21	0.86	9.60	2.38	0.88
22	7.18	0.79	12.02	2.24	1.02
23	7.13	0.73	8.97	2.80	1.00
Range	7.01-7.72	0.65-0.98	6.87-12.58	2.18-3.30	0.41-2.30
Mean	7.25	0.83	9.93	2.73	1.28
Davanagere Taluk					
1	8.16	0.81	10.23	4.90	1.49
2	8.13	0.83	9.60	4.59	1.58
3	8.43	0.95	6.32	3.88	1.05
4	8.26	0.96	6.90	4.50	1.40
5	8.29	0.89	10.76	4.90	1.55
6	8.58	0.85	9.60	4.43	1.62
7	8.53	1.06	9.29	4.43	1.47
8	8.24	1.16	10.18	4.96	2.41
9	8.17	1.20	9.30	3.88	1.66
10	8.12	1.06	10.77	5.89	1.64
11	8.26	1.19	8.70	3.81	1.46
12	7.19	0.88	5.68	2.48	1.94
13	7.03	0.89	8.10	2.15	1.89
14	7.58	0.82	8.87	2.48	1.37
15	7.52	0.83	8.67	2.33	1.56
Range	7.03-8.58	0.81-1.20	5.68-10.77	2.15-5.89	1.05-2.41
Mean	8.03	0.96	8.86	3.98	1.61

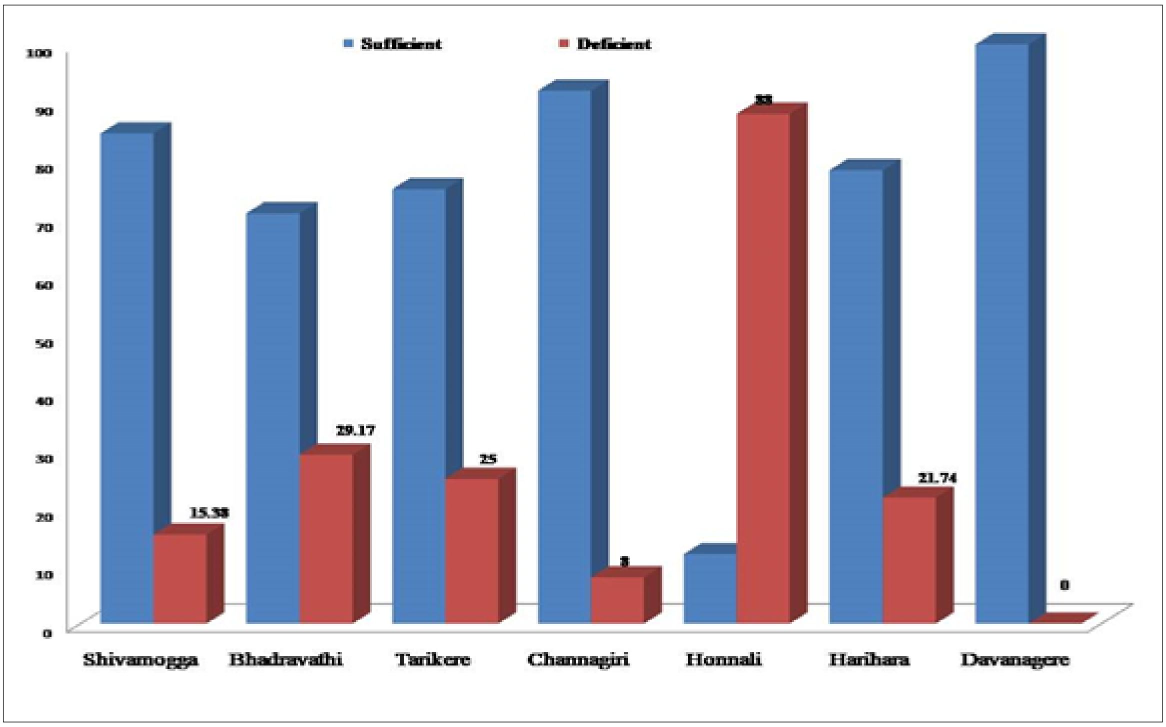

Fig 2: Sufficiency and deficiency status of available zinc in soils under paddy cover of different taluks coming under Bhadra command of Karnataka

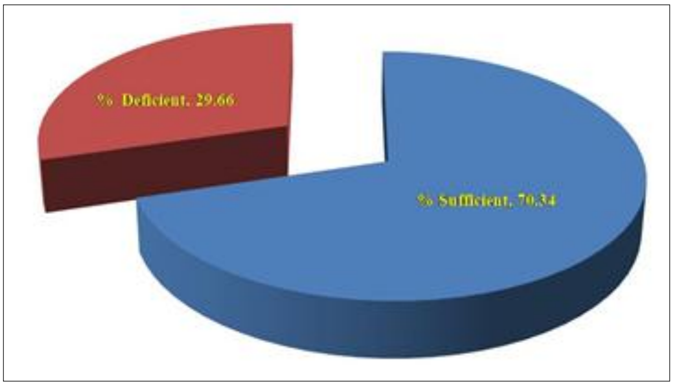

Fig 3: Sufficiency and deficiency status of available zinc in soils under paddy cover of Bhadra command, Karnataka

4. Conclusion
Available zinc status in the surface layer of soils coming under paddy land use cover of Bhadra command was found that 29.66 per cent of samples recorded deficient status and the remaining 70.34 per cent of samples were sufficient in available zinc status due to regular addition of ZnS04 to paddy fields. Available zinc was found to be positively influenced by total zinc content and soil properties like pH, organic matter, CaCO3 and clay content of soils.

5. References

1. Ananthanarayana R, Perur NG. Characterization of some acid soils of and fate of Zinc applied to the soil. J. Indian Soc. Soil Sci. 1973; 25(4): 426-432.
2. Binita NK, Dasog GS, Patil PL. Soil fertility mapping in Ghataprabha left bank command area of north Karnataka by geographic information system technique. Karnataka J. Agric. Sci. 2009; 22(1):73-76.
3. Brady AC, Weil RR. The nature and properties of soils, 13th Edition, Prentice Hall, New Jersey, 2002.
4. Chidanandappa HM. Dynamics of zinc and copper in organic materials amended soils, Ph D thesis submitted to UAS Bangalore, 2003.
5. Deka AK, Poonia SR. Effect of FYM on cobalt sorption in soils from semi-arid and humid regions. J. Indian Soc. Soil Sci. 1977; 45(1):62-66.
6. Duraisamy P, Kothandaramam GV, Chellamuthu S. Effect of amendments and zinc on the availability, content and uptake of zinc and iron by rice Bhavani in sodic soil. Madras Agric. J. 1988; 75:119-124.
7. Grewal JS, Sharma RC, Sud KC. Effect of continuous application of PK fertilizers and FYM on potato yield and some properties. J. Indian Soc. Soil Sci. 1981; 29(1):129-131.
8. Jyoti PM, Sureshbhai P. DTPA – Extractable micronutrients and fertility status of soil in Shirpur Tahasil region. Int. J. Chem. Tech. Res. 2012; 4(4):1681-1685.
9. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Am. J. 1978; 42:421-428.
10. Meena HB, Sharma RP, Rawat US. Status of macro and micronutrients in some soils of Tonk district of Rajasthan. J. Indian Soc. Soil Sci. 2006; 54:508-512.
11. Page AL, Miller RH, Keeney DR. Methods of soil analysis, Part-2, Chemical and microbiological properties (2ndEd).Am. Soc. Agronomy Soil Sci. Am. Inc.,public. Madison, Wisconsin, United States of America, 1982.
12. Rajeswar M, Sujini CR, Balaguravaiah D, Khan MAA. Distribution of available macro and micronutrients in soils of Garikapadu of Krishna district of Andhra Pradesh. J. Indian Soc. Soil Sci. 2009; 57(2):210-213.
13. Rama D, Prakash CS. Effect of zinc sulphate application and the cyclic incorporation of cereal straw on yields, the tissue concentration and uptake of Zn by crops and availability of Zn in soil under rice–wheat rotation. Int. J. Recycl. Org. Waste Agricult. 2014; 53(3):185-194.
14. Ravikumar MA, Patil PL, Dasog GS. Mapping of nutrient status under 48A distributory in Malaprabha right bank command of Karnataka by geographic information

system technique-II: Micronutrients. Karnataka J. Agric. Sci. 2007; 20(4):738-740.
15. Selvaraj S, Basavaraj B, Hebsur NS. Distribution of different forms of zinc in paddy growing soils in selected villages of Gangavati Taluk, North Karnataka. Research J. Agric. Sci. 2012; 3(6):1170-1174.
16. Sharma RP, Singh M, Sharma JP. Correlation studies on micronutrients vis-a-vis soil properties in some soils of Nagaur district in semi-arid region of Rajasthan. J. Indian Soc. Soil Sci. 2003; 51:522- 527.
17. Shivaprasad CR, Reddy RS, Niranjan KV, Dhanorkar B A, Naidu LG. NBSS and LUP, Ann. Rep., April 1995, March 1996, ICAR Publications, Nagpur, 1996, 12.
18. Singh MV. Saha J. In 26th Progress Report of the All India Coordinated Scheme of micro and secondary-nutrients and pollution elements in soils and plants (1993-94-95) IISS, Bhopal, 1995.
19. Takkar PN. Micronutrient research and sustainable agricultural productivity in India. J. Indian. Soc. Soil Sci. 1996; 44(4):562-581.