P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(2): 1746-1749

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Received: 16-01-2020

Accepted: 18-02-2020

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Delineation and mapping of micronutrients status in the rice soils of Kasargode district of Kerala

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i2aa.9012>

Abstract

Micronutrient deficiency in soil has become widespread in recent years and has resulted in low crop yields. Information on micronutrient status of rice soils is very much relevant for identifying constraints in rice production and to develop judicious fertilization to attain sustained productivity. The midland rice fields in Kasargode district constitute the drainage basins of hills and hillocks. Soil is lateritic and acidic in nature with high accumulation of reduced forms of iron and manganese and invariably poor in micronutrients boron, copper and zinc. In the present investigation 3500 surface soil samples were collected from selected 175 paddy fields of Kasargode and assessed for extent of soil acidity and available (0.1N HCl extractable) micronutrient status. Soil acidity is a serious constraint in these soils, which are very strongly acidic to neutral in reaction with pH values ranged from 4.21 to 7.44. The content of 0.1 N HCl extractable Fe, Mn, Zn and Cu in soil varied from 52.21 – 414.9, 12.21 – 54.80, 0.66 – 38.5, 0.18 – 36.5 mg kg⁻¹ respectively and hot water soluble boron varied from 0.027 – 0.948 mg kg⁻¹. The available copper and zinc were found to be adequate and hot water soluble boron was deficient in these soils. The soil available iron and manganese was found to be excess and iron toxicity (> 200 mg kg⁻¹) problem was also observed in some soils of the study area.

Keywords: Rice soils, micronutrients, soil acidity, iron toxicity, GIS mapping

Introduction

Land use plays a vital role in governing the nutrient dynamics and soil fertility (Venkatesh *et al.*, 2003). Assessment of soil properties along with nutrient status particularly micronutrients of various land use system is important for identifying soil constraints and for attaining sustained productivity (Somasundaram *et al.*, 2009). Availability of micronutrients is influenced by their distribution in soil and other physico – chemical properties of soil.

The midland rice fields in Kasargode district constitute the drainage basins of hills and hillocks, soil being lateritic and acidic in nature with high accumulation of reduced forms of iron and manganese and invariably poor in micronutrients. The present investigation was undertaken to study the extent of soil acidity and status of available micronutrients viz., Fe, Mn, Zn, Cu and B in rice ecosystems of Kasargode.

Materials and methods

The selected midland rice fields of Kasargode situated in the northern part of Kerala lies between 12° 06' 41'' and 12° 41' 32'' N latitude and 74° 59' 31'' and 75° 15' 59'' E longitude. The average elevation is 50 to 300 m above mean sea level. 3500 surface (0-15 cm) soil samples at random were collected from selected rice growing fields during 2015 and 2016 to assess the extent of soil acidity and available micronutrient status of soil.

Soil pH was determined in 1:2.5 (soil: water) suspension using pH meter. The available Fe, Mn, Zn and Cu in soils were extracted with 0.1 N HCl extract and the quantity was determined using AAS. The available B was extracted with hot water and quantified using spectrophotometer after developing colour using azomethine – H reagent. The data were interpreted as deficient and sufficient based on the critical level of nutrients suggested by KAU. Iron toxicity problem in the study area was also estimated based on the critical values. The maps on available boron status and iron toxicity were prepared using Arc GIS software.

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Results and discussion

Soil acidity

The pH values of rice soils are given in Table 1, which varied from 4.21 to 7.44 indicating that the soils are very strongly acidic to neutral in reaction except Padana soils where pH was 6.17 to 9.56 (neutral to alkaline reaction). The lowest pH was recorded in Pilicode and the highest in Padana. The reasons for the low pH is that the rice soils are lateritic and derived

from acidic parent material. The dominance of Fe, Mn and Al in these soils also contribute to soil acidity due to the hydrolysis of these ions in exchange sites of soil complexes. Similar results were also reported by Jena (2013) [2]. The higher pH in Padana soils is attributed to the high amount of alkaline earth minerals and intrusion of sea water into rice fields.

Table 1: Soil acidity in rice soils of Kasargod

S. No.	Location	pH		S. No.	Location	pH	
		Range	Mean			Range	Mean
1	Pilicode	4.21-6.14	5.32	16	Kumbla	5.36-6.12	5.88
2	Cheruvathur	4.37-5.92	5.43	17	Enmakaje	4.55-5.67	5.23
3	Padana	6.17-9.56	7.91	18	Nileswar	3.76-5.36	4.67
4	Trikaripur	4.53-6.28	5.54	19	Kasargode	4.97-5.02	5.00
5	Kodombelur	4.93-6.58	5.82	20	Chengala	4.45-5.48	5.04
6	Kinanur	4.75-5.33	5.17	21	Manjeswar	5.94-7.08	6.63
7	Kanhangad	4.57-7.44	6.13	22	Vorkadi	5.57-6.84	6.37
8	Kayyur Chemeni	4.59-5.75	5.21	23	Mangalpady	4.71-6.31	5.56
9	Chemnad	5.16-5.31	5.26	24	Panathady	6.07-6.41	6.19
10	Uduma	5.43-5.81	5.69	25	Kallar	5.93-6.30	6.03
11	Pallikara	4.63-5.64	5.25	26	Karadukka	4.93-5.76	5.41
12	Pullur Periya	4.28-5.75	5.28	27	Muliyar	5.01-5.75	5.31
13	Puthige	4.91-5.45	5.24	28	Paivaligai	5.50-6.85	6.33
14	Kuttikol	4.88-5.55	5.30	29	Belur	5.18-6.55	5.72
15	Meencha	5.76-6.17	6.01	30	Kumbadaje	5.43-6.95	5.66

Available micronutrients

Table 2: Available micronutrient status in rice soils of Kasaragode.

S. No.	Location	Av. Cu (mg kg ⁻¹)		Av. Zn (mg kg ⁻¹)		Av. B (mg kg ⁻¹)		Av. Mn (mg kg ⁻¹)		Av. Fe (mg kg ⁻¹)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	Pilicode	0.18 – 1.94	0.72	3.18 – 18.53	11.03	0.08 – 0.624	0.35	13.10 – 25.53	17.81	12.21 – 269.5	201.7
2	Cheruvathur	1.54 – 5.51	3.66	2.78 – 11.59	8.35	0.027 – 0.186	0.16	22.58 – 41.59	34.79	173.6 – 349.4	275.4
3	Padana	1.23 – 4.21	3.17	2.23 – 8.56	5.11	0.153 – 0.236	0.19	12.21 – 18.55	14.23	112.6 – 240.7	176.9
4	Trikaripur	0.47 – 3.88	2.10	0.66 – 3.69	4.99	0.136 – 0.678	0.42	20.62 – 33.59	26.04	59.63 – 114.8	87.1
5	Kodombelur	4.38 – 10.67	6.79	2.26 – 9.27	6.46	0.284 – 0.873	0.56	12.36 – 29.20	18.37	83.62 – 234.5	149.6
6	Kinanur	4.66 – 11.52	7.41	7.15 – 25.84	14.34	0.365 – 0.948	0.64	27.15 – 45.24	34.21	73.09 – 188.3	152.4
7	Kanhangad	2.52 – 27.34	12.26	3.52 – 18.75	12.06	0.245 – 0.683	0.59	31.52 – 38.05	34.06	57.7 – 288.5	174.2
8	Kayyur Chemeni	3.36 – 19.65	10.61	0.59 – 15.97	9.64	0.123 – 0.845	0.42	21.59 – 54.80	31.32	112.4 – 303.2	173.4
9	Chemnad	9.55 – 11.82	10.44	13.16 – 19.25	15.09	0.085 – 0.226	0.16	17.16 – 39.20	26.39	188.5 – 382.4	227.5
10	Uduma	8.91 – 13.85	9.98	1.57 – 5.41	2.96	0.183 – 0.295	0.23	21.50 – 45.41	31.47	152.8 – 188.5	169.8
11	Pallikara	4.87 – 7.78	6.07	3.14 – 8.66	5.02	0.096 – 0.274	0.14	30.54 – 48.16	38.06	153.5 – 299.3	173.4
12	Pullur Periya	4.6 – 9.01	6.24	1.39 – 6.37	3.17	0.157 – 0.648	0.31	14.09 – 26.37	19.26	42.85 – 225.8	104.6
13	Puthige	12.57 – 27.48	18.46	12.16 – 19.79	14.18	0.245 – 0.328	0.28	12.96 – 39.70	22.38	127.1 – 302.6	174.1
14	Kuttikol	6.21 – 9.66	7.91	29.72 – 38.15	32.31	0.155 – 0.389	0.24	24.72 – 40.15	31.49	162.5 – 307.6	203.8
15	Meencha	6.95 – 15.53	10.63	0.66 – 3.58	1.24	0.327 – 0.745	0.47	20.66 – 39.58	29.71	36.33 – 132.8	74.3
16	Kumbla	7.12 – 15.40	11.49	3.56 – 11.23	6.38	0.086 – 0.434	0.19	13.26 – 31.20	18.98	147.4 – 270.2	176.2
17	Enmakaje	7.9 – 12.44	9.66	20.05 – 31.12	24.16	0.158 – 0.325	0.25	20.05 – 31.12	24.63	97.71 – 180.3	131.8
18	Nileswar	1.76 – 11.28	6.41	1.44 – 16.67	7.63	0.158 – 0.718	0.41	20.44 – 50.67	28.46	186.9 – 414.9	243.6
19	Kasargode	6.87 – 15.34	10.07	8.80 – 11.64	9.04	0.146 – 0.385	0.28	28.80 – 31.64	29.03	58.52 – 74.12	69.3
20	Chengala	5.51 – 9.73	7.03	3.68 – 10.95	6.07	0.263 – 0.568	0.36	30.68 – 40.90	34.21	80.76 – 146.1	102.4
21	Manjeswar	4.32 – 10.75	6.98	3.80 – 15.86	7.96	0.252 – 0.625	0.42	23.00 – 40.83	28.97	88.26 – 198.4	132.7
22	Vorkadi	6.73 – 27.15	17.32	4.60 – 11.51	8.32	0.216 – 0.473	0.33	34.60 – 51.21	46.23	123.1 – 209.5	142.8
23	Mangalpady	15.04 – 23.73	18.47	0.76 – 5.66	2.43	0.212 – 0.486	0.36	28.76 – 35.66	31.04	6.25 – 35.28	18.7
24	Panathady	4.77 – 12.85	7.14	6.14 – 9.23	7.05	0.342 – 0.508	0.43	23.14 – 39.13	29.67	118.2 – 190.6	149.6
25	Kallar	0.76 – 10.44	5.91	4.53 – 7.94	5.41	0.287 – 0.723	0.52	40.53 – 47.34	43.32	49.45 – 308.1	123.8
26	Karadukka	7.86 – 36.5	20.03	19.97 – 28.72	23.06	0.082 – 0.427	0.21	30.97 – 48.72	38.91	138.5 – 183.6	151.2
27	Muliyar	12.54 – 23.45	15.46	0.73 – 15.97	6.32	0.105 – 0.298	0.19	21.57 – 39.01	29.41	82.01 – 175.2	102.7
28	Paivaligai	18.75 – 31.41	24.61	4.24 – 10.18	6.97	0.168 – 0.392	0.26	14.24 – 30.18	19.13	7.66 – 19.38	11.3
29	Belur	14.92 – 17.56	15.12	9.69 – 13.65	11.04	0.264 – 0.835	0.47	19.59 – 32.50	24.61	86.65 – 135.6	102.8
30	Kumbadaje	3.98 – 6.27	4.82	5.87 – 11.38	7.13	0.064 – 0.289	0.16	15.87 – 27.23	18.97	27.36 – 80.66	49.3

Available zinc

The available Zn content in soil varied from 0.66 – 38.15 mg kg⁻¹. The lowest value was observed from Trikaripur and the highest from Kuttikol. The available Zn content is adequate in 98% and deficient in 2% samples while considering the critical limits for Zn <1 mg kg⁻¹ is deficient, >1 mg kg⁻¹ is

adequate and >40 mg kg⁻¹ is high (fig. 1). The solubility of native as well as applied zinc is highly pH dependent and the acid pH that occurs in the soil is expected to enhance the solubility of Zn which might have increased the available Zn in the soil. This is in agreement with the findings of Sharma *et al.* (2003) [3].

Fig 1: Frequency of Zinc classes (n = 3500)

Available copper

The available copper content in soil varied from 0.18 to 36.5 mg kg⁻¹. The lowest value was observed from Pilicode and the highest from Karadukka. On the basis of the critical limits suggested for soil available copper <1 mg kg⁻¹ for deficient, >1 mg kg⁻¹ for adequate and >20 mg kg⁻¹ for high, 2.9% samples are deficient, 89.8% adequate and 7.3% high in available Cu (fig.2). The amount of copper released in soil solution depends on soil pH, with the increase in soil pH the amount of available Cu in soil decreases. The solubility and mobility of copper in soil also decreases with increased pH and a significant negative relationship exists between pH and amount of available Cu. The low pH in these soils might have increased the solubility and availability of Cu in soil as reported by Das (2007) [1].

Fig 2: Frequency of Copper classes (n = 3500)

Available Boron

The hot water-soluble boron content in soil varied from 0.027 to 0.984 mg kg⁻¹. The lowest value was observed from Cheruvathur and the highest from Kinanur. As per the critical values suggested for boron viz., <0.5 mg kg⁻¹ for deficient, 0.5-2.0 mg kg⁻¹ for adequate and >2.0 mg kg⁻¹ for high, 91% of the soils were found to be deficient and 9% adequate in soil available boron (fig. 3). The highest rate of deficiency for boron in the soils is attributed to the strong acidity prevails in that soil. The soils being lateritic, high amount of available Fe and Al form complex with B and might have reduced its availability in soil. The deficiency is also more pronounced in high rainfall areas where B is leached from the soil as reported by Das (2007) [1].

Fig 3: Frequency of Boron classes (n = 3500)

Available Manganese

The available manganese content in soil ranged from 12.21 – 54.80 mg kg⁻¹ and is in the excess range (critical limit is 1.0 mg kg⁻¹). The lowest value was observed from Padana and the highest from Kayyur Chemeni. This is attributed to the dominance of parent material in manganese bearing mineral and also the lateritic soils with low pH contains large concentration of Mn²⁺ in solution because of the increased solubility of Mn bearing minerals which is similar with the results reported by Wani *et al.* (2010) [6].

Available Iron

All the soils under study fall under excess (> 5 mg kg⁻¹) category for available iron status. The content of 0.1 N HCl extractable Fe in soil varied from 6.25 – 414.9 mg kg⁻¹. The lowest value was observed from Mangalpady and the highest from Nileswar. Toxic concentration of iron was also observed in some soils of the study area which is given in table 2. The concentration of Fe²⁺ increases due to the reason that the midland rice fields of study area constitute the drainage basins of hills and hillocks, which accumulates all the leachates washed down from hills and the soils being lateritic which are high in iron content, the extent of reduced forms of iron accumulating is also high as reported by Jena (2013) [2] in acid soils of Odisha.

Conclusion

From the study it is concluded that the rice soils of Kasaragode are strongly acidic to neutral in reaction, deficient in boron and adequate in copper, zinc, iron and manganese. Toxic concentrations of iron was also present in some soils. The results suggest the need of boron fertilization in these soils to enhance rice production and also lime application to reduce soil acidity and iron toxicity problems.

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